The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 20. JUNE, 1918. No. 198.

PUBLISHED THE FIRST WEEK IN EACH MONTH

Subscription Terms: 7s. 6d. per annum, post free.

To place the "Journal" within the reach of working Moulders and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
165, Strand, London, W.C.

OWING TO THE REDUCTIONS IMPOSED BY THE GOVERNMENT ON PAPER SUPPLIES, THE PROPRIETORS ARE COMPELLED TO PUBLISH "THE FOUNDRY TRADE JOURNAL" ON A THIN PAPER DURING THE CONTINUANCE OF THE RESTRICTIONS.

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Forthcoming Event.

JUNE 21 AND 22.

British Foundrymen's Association:—Annual conference, at Sheffield.

June 21.—Presidential address, by Thos. H. Firth; "Deformity of Castings," by T. Brown; "Fluidity of Molten Cast Iron," by M. Riddell.

June 22.—"A National Information Bureau for Foundrymen," by R. Buchanan; "Influence of some Special Elements on Cast Iron," by Prof. A. Campion.

NOTES AND COMMENTS.

Foundrymen's Annual Meeting.

For three years past the annual meeting of the British Foundrymen's Association has been shorn of the social functions, as well as the presentation of papers and lectures, which in pre-war days constituted an attractive part of the programme. This year, however, it has been wisely decided by the Council to resume the reading of papers and, to some extent, the social features. On the 21st and 22nd of this month the members will meet in Sheffield, the home of the President-Elect, Mr. Thos. H. Firth, whose popular personality, coupled with the industrial attractions of the city itself, should ensure an excellent attendance. The first day's programme includes two papers, on "Deformity of Castings," by Mr. T. Brown, and "The Fluidity of Molten Cast Iron," by Mr. M. Riddell, respectively. These will be followed by a lunch at Grand Hotel, and a visit to the steel foundries of Messrs. Thos. Firth & Sons, Limited, Norfolk Works, Shefield. In the evening the President will entertain the members to dinner at Grand Hotel. The second day's programme includes a paper on "A National Information Bureau for Foundrymen," by Mr. R. Buchanan, and one on "The Influence of Some Special Elements Upon Cast Iron," by Professor A. Campion (Glasgow), The foregoing is, of course, a modest programme compared with those of pre-war days, but it is a distinct improvement on the purely business meetings of the past few years. The fact that Branch activities have been so well maintained during the war indicates that the technical and educational work of the Association is valuable and appreciated by the trade. Therefore, we can only regard with pleasure the resumption of discussions at the annual meeting.

A Foundry Information Bureau.

Much interest will centre on the paper to be presented by Mr. Buchanan on "A National Information Bureau for Foundrymen," and doubtless members will freely air their views on what has at last come to be regarded as a foundry-trade necessity. For years we have urged the Association to deal with this necessity, and use the weight of its influence to start such a bureau. In the early days of the war the necessity was seriously felt by many founders, who were suddenly confronted with new problems arising out of a change in the nature of their work; but the Association's Council at the time did not see the way clear to take action in the matter. This can be understood, for each member, as an individual, found his time so fully occupied with urgent war work as to preclude attention to starting a new organisation, no matter how useful it might be eventually. Since, however, the trade is badly in need of some organisation which will collect and centralise information on founding, it is for such bodies as the

British Foundrymen's Association to take the initiative and enlist all possible help, both private and Government.

It is to be hoped that at the Foundrymen's meeting this month the subject will be well ventilated and a bold and comprehensive scheme devised. To be conservative at the initial stages is to hamper the development of the scheme indefinitely. Financial support, naturally, is one of the first essentials, but that would almost certainly follow the initiation of any promising scheme for supplying the trade with the information it needs. Probably a greater difficulty at the moment will be experienced in obtaining competent workers who can devote sufficient time to the work to set the scheme rapidly on a sound basis. This can best be determined by free discussion of the difficulties by the men concerned—i.e., the representatives of the trade who will be present at the Foundrymen's meeting, for the Association is certainly a representative one, embracing all branches of founding craft and science, and it has a membership which lifts it above the level of mediocrity. We await with hopeful interest, and an assurance of all possible support, the development of an idea which has now had ample time to germinate, and requires to be stimulated to material growth.

Zirconia as a Refractory.

Zirconia has come much to the front of late as a refractory for furnace lining and similar purposes, not the least important of these being the lining of electric furnaces of the arc type. Owing to its high melting point, low thermal conductivity and low co-efficient of expansion it is, of course, particularly suitable also for lining steel furnaces and all furnaces where high temperatures are required or where very active slags are employed. It has a distinct application in the manufacture of crucibles for special purposes, such as the melting of nickel or of such other metals as will attack all other commercially known crucibles. It has an important bearing in the manufacture of glass; it may be used also as the base for the manufacture of paints and enamels, including acid-resisting enamel; and forms with iron and other metals valuable alloys which have great commercial possibilities.

It is, however, only comparatively recently that the commercial possibilities of zirconia have received serious attention in this country. Obviously the first consideration was the purification of the ore, next the discovery of a suitable binder; indeed, without this last the first would be of comparatively small value. Acting on behalf of a group of manufacturers in this country, Messrs. Coley & Wilbraham, Limited, Bury Street, St. Mary Axe, London, have been engaged upon the investigation of zirconia from a commercial point of view for the past two years, the outcome of their exhaustive experiments being the production of a practically pure oxide (ZrO_2), which can be produced on a commercial scale. They have at the same time evolved a binder which will enable the zirconia bricks to be used for linings which will withstand the highest temperatures employed in some industries.

It will, of course, be readily understood that zirconia is by no means a low-priced refractory; we use the term "low-priced," as opposed to "cheap," advisedly, because in this instance, as indeed is often the case, the higher priced article is possibly the cheaper. Users of refractories will not concern themselves about the actual cost of renewing a lining, but rather with the proportion which cost bears to the ton of saleable material produced. It will be remembered that a zirconia-lined hearth of a Siemens-Martin furnace at Remscheid in Germany after four months' continuous working, at high temperature, was still in good condition and capable of running for at least an equal additional period of time. From the foregoing the importance of the commercial development of zirconia will be self-evident, and it may well mean the establishment of an important industry in this country which will enable us the better to hold our own after the war.

Importation of Timber.

The Controller of Timber Supplies announces that, in addition to arrangements previously announced, applications for licences to import timber from Canada and the United States of America will now be recommended to the Department of Import Restrictions on the following terms:—

Shipment.—(*a*) In any unrequisitioned space under deck of British or Allied liners or steamers. (*b*) In neutral steamers, subject to the approval of the Inter-Allied Chartering Executive, Holland House, Bury Street, E.C.3, to whom application for permission to charter must be made before application is made for a licence to import.

Conditions.—(*a*) The timber must not displace foodstuffs or munitions. (*b*) Shipment is to be made within three months of the application for import licence, otherwise the licence, if granted, will become void. (*c*) Importers must agree to be bound by the rules as to prices contained in the War Office letter of February 8, 1917, and by the communiqué to the Press, dated July 20, 1917.

These rules provide that in the case of softwood, the timber may be sold by the importers at its cost price, delivered to store, plus 10 per cent., provided that the price so calculated does not exceed by more than a third the prices current during the last week of January, 1917, for softwood of similar quality and description in the same locality. The timber may be sold by persons other than the importers at prices which are in accord with the foregoing proviso.

THE ELECTRIC FURNACE IN SWEDEN.—According to an Italian writer, there were in Sweden at the beginning of 1916 about ten electric furnaces ranging from 2,000 to 3,000 kw., viz., at Domnarfvet, two furnaces of 3,000 h.p. and one of 6,000 h.p., all working; at Söderfos, three furnaces of 3,000 h.p. under construction; at Ljusne, one furnace of 3,000 h.p. under construction; at Hagfos, three furnaces of 3,400 h.p. under construction; at Trollhättan, one furnace of 2,000 h.p. working and one of 3,000 h.p. under construction. Some of these furnaces were finished in 1916, and it is reckoned that the output of electric pig-iron will greatly exceed that of 1915. Besides these, there is a large number of steel furnaces which treat either cast or scrap iron or else refine ordinary steel; their output at present is about 100,000 tons yearly. According to observations and calculations made, a complete works fitted with three furnaces of 3,000 or 4,000 h.p. capacity would cost before the war about £16,000 per furnace; the working requirements of each 3,000-h.p. furnace turning out 20 metric tons of iron per effective working day being, per ton:—Anthracite coal, 660 lbs.; electrodes, 11 lbs.; lime, 236 lbs; electrical energy, 2,116 k.w.-hours; labour, 2s. 6d. Such a furnace would require the services of 30 men for all purposes.

Steel Castings Design and Manufacture.*

The development of heavy machinery in the metallurgical industries on the one hand, and of extremely light mechanisms in electrical and automobile apparatus on the other, to quote two extreme examples, has called for the production of massive and delicate cast and wrought details capable of withstanding the highest possible stresses and of the lightest permissible weight.

The disadvantages arising from the slow solidification and cooling of heavy cast-iron masses such as the cylinders and heads of large hydraulic presses of high power have demanded a better and stronger material. It has long been recognised that the central zones of heavy cast-iron sections are so coarsely crystalline, weakened by graphitic carbon, and porous by reason of gas cavities and fissures due to contraction strains, that the allowable working stresses must be taken at very low values. The designer is thus often obliged to increase the metal thickness of a casting beyond the point where the crystalline intercohesion in the

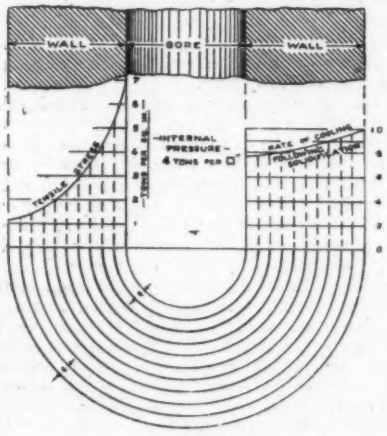


FIG. 1.

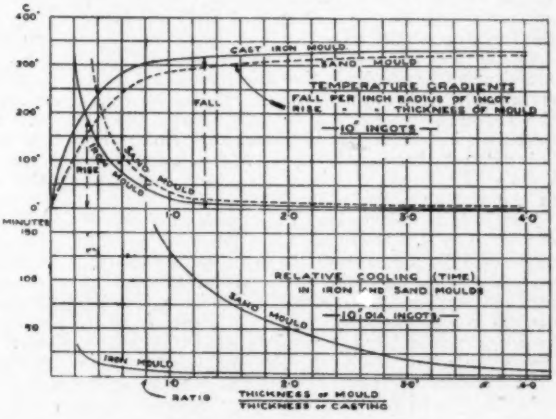


FIG. 2.

centre of the section is too weak to fix a tensile value for it. To make the section strong enough to withstand the necessary working load it has often, in the case of cast iron, been necessary to make it so massive that its centre cools too slowly for it to possess any appreciable strength.

The design of hydraulic cylinders is a case in point. The estimated thickness for a 20-in. cast-iron cylinder to withstand a bursting pressure of 5 tons per sq. in. is, say, 16. in. Such a mass of cast-iron cools so slowly that it would be coarsely crystalline; the central third of the wall thickness would consist of metal having an ultimate strength of not more than three or four tons per square inch, thus reducing the virtual thickness to, say, 10 or 11 inches. In addition to this trouble there would be the accompanying risk that the metal might be so porous as to prevent any high hydraulic pressure being carried.

There is the further fact that the outer zones of a thick cylinder wall are, under hydraulic pressure, stressed more lightly than the inner zones nearest the bore. (See Fig. 1.) During the freezing and cooling of the metal the rate of cooling of the layer next to the bore is slower than that adjacent to the outer surface, as can readily be proved by comparing the values of C/S, where C is the cooling surface in sq. ins. of a ring of sections one inch deep and S equals the cubic contents of an annular ring of thickness ϵ inches. It will be seen that the value of C/S for the outer ring is greater than that for the inner ring. In a cylinder 15 in. bore and 10 in. thick the relative rates of cooling are 2.02 in the outer ring to 1.93 in the inner ring. By such considerations it will be found that cooling travels more slowly from the bore outwards than from the outer surface inwards. Similarly, the contact-heating of the mould at the outer circumference of the cylinder casting proceeds more rapidly than that at the surface of the core in the proportion (in the case quoted) of 55 to 48. The core therefore becomes heated more rapidly than does the outer mould surface, and, as shrinkage proceeds, air contact at the outer circumference further speeds up the cooling action there because the specific conductivity of air is greater than that of sand and other insulators, as is shown in the need for steam-pipe covering to prevent heat radiation. Again, the expansion of the core keeps the sand longer in contact with the metal and cooling is slowed down thereby. Such investigations reveal the fact that the coarse crystallisation occurs in the layers nearest to the cylinder core, where it has been shown that cooling is slowest and where in hydraulic service the metal stresses are greatest. Fig. 1 illustrates the foregoing.

Fractured cylinders prove the above to be the case, coarse graphite structures being revealed near to the inner surface. Through this porous region the high-pressure working fluid percolates and failure to resist such pressures in thick cylinders is explained. Years ago it was found necessary to cast such cylinders with walls not exceeding 10 ins. thick, as it was found that beyond this thickness the cylinder was not increased in strength. Mr. P. R. Jackson mentioned at a meet-

*Read before a joint meeting of the Staffordshire Iron and Steel Institute and the Birmingham Branch of the British Foundrymen's Association, February 23, 1918. Mr. J. Shaw in the chair.

ing of the Institution of Mechanical Engineers in 1874, that forty years before he had constructed 21-in. cylinders of rather hard, close-grained iron, surrounding them by wrought-iron hoops. He recognised the interior porosity and overcame it by lining the cylinder with copper or brass, thus enabling heavy pressures to be carried. By similar reasoning based on the laws of cooling and supported by tests taken from various portions of thick iron castings it is clear that thicknesses exceeding 5 or 6 ins. in castings made in sand moulds are more or less unreliable, the interior of the heavy sections being fissured by graphitic flakes and porous, often containing gas inclusions as the result of imperfect feeding. Moreover, it has not been sufficiently recognised that the recalescence which occurs in steels when cooled past about 700 deg. C., and is accompanied by dilatation or swelling, also occurs in cast-iron. This is masked by the fact that the porosity which invariably accompanies coarse graphitic separation allows the internal dilatation to occur without visible or external deformation of the castings. There is, however, internal expansion, and this must be associated with a further opening out of the fissures which are primarily started when the graphite separates out during and immediately following the freezing of the iron.

In the manufacture of malleable cast-iron, it is found necessary to limit the silicon content of the metal used for heavy castings to, say, 0.5 per cent., the object being to prevent the formation of graphite in cooling, and Professor Howe has pointed out that in the U.S.A. it is common to limit similarly the silicon content for metal used in the casting of hydraulic cylinders.

The lack of uniformity in malleable cast-iron of any considerable thickness has often been pointed out, and it is well known that thicknesses of 2 in. and over, even in metal containing less than 0.5 per cent. silicon, give trouble. The annealing necessary to decarburise the outer envelope leads to coarse-grained crystallisation in the heart of the castings. The great difficulty in getting regular results in malleable cast-iron is due largely to the impossibility of securing initial graphiteless uniformity in the pig-iron used in its manufacture, or, more correctly, in the unannealed castings. It has been rightly contended that silicon alone does not give a true index to the casting condition before annealing. The relation of silicon to the total and combined carbon is essential and indeed vital.

The above has been introduced to illustrate the fickleness of the material dealt with by the malleable-iron founder, and to indicate the difficulties of making heavy castings which will anneal satisfactorily. Heavy castings require metal having lower than 3 per cent. of total carbon and this is difficult to procure. Moreover the castings made are brittle in the cast state and needs careful handling during cooling, and slowly cooling down in a special furnace to avoid contractional fractures; contraction of such iron reaching ¼-in. per foot. The lighter and thinner castings, say up to ½-in. thick, can be made of relatively softer irons, lower in sulphur and higher in total carbon; they are easier to cast and to anneal. The light malleable casting has thus an important domain, and its soundness and generally satisfactory character places it in a firm position for intricate forms which cannot readily be cast in steel cheaply or drop-forged.

It has been shown, therefore, that there are certain fundamental difficulties in connection with the manufacture of heavy cast-iron castings exceeding, say 5 in. in thickness, and of malleable cast-iron castings exceeding, say, 1 in. thick. This calls for a more reliable and readily manipulated material, and in steel the general characteristics sought for are to hand. The general homogeneity of well melted steel enables the founder to deal with masses of almost any weight, though it is perhaps safe to say that thicknesses of above 12 ins., except in castings of easy form and such as can readily be fed, give trouble in similar ways to cast-iron in heavy masses. Segregations of carbon, sulphur, phosphorus, in various combinations, together with slag and gas inclusions appear in the areas last to solidify.

Steel freezes so rapidly that any such inclusions become entrapped to a much larger extent than occurs in cast iron, where during the slower freezing the gases and oxides can escape more readily to the freezing heads, their places being replaced by liquid feeding metal. The higher casting temperature of steel, however, complicates matters, as does the dilatation or expansion which accompanies the recalescence during cooling. These two factors, along with the accidental though largely unavoidable presence of occluded gases and migratory slag, sulphide and phosphide particles, account for most of the difficulties which are experienced in steel founding.

High casting temperatures are associated with extremely fluid metal though not infrequently with abnormally large quantities of occluded gases. Such hot mobile steel is extremely erosive, and demands that the mould surfaces shall be of suitable material and of sufficiently rigid and uniform character. Now moulds for cast-iron have to resist rather acid metal at temperatures rarely exceeding 1,300 deg. C. These can be made of a readily procurable sand mixture, porous in character and containing a fairly high percentage of binding elements, and of volatile constituents which at the temperature of pouring leave ample exit paths for the escape of gas and moisture liberated at the mould surface when in contact with the fluid metal. Just as in the case of iron foundries where the floor sand has been repeatedly used so often as to yield bad and scabby castings, so with steel moulding sands and compositions. These can be so repeatedly used that the individual grains split up into smaller ones until the percentage of fines becomes too great to allow of proper gas porosity or permeability, and the added fireclay binding is found agglomerated in colonies of fusible character. This non-homogeneity in a mass which should be uniformly porous and coherent leads to uneven skin expansions and contractions when under the influence of the adjacent molten metal, surfae fissuring being the result. Even during the drying of the moulds such fissuring can commonly be seen, and these cracks are repaired more or less efficiently—where they can be readily got at. Where they cannot be so repaired the result is seen in the crocodile-hide form of skin which, with the scab as its neighbour (where the mould cracks have been repaired hurriedly with damp material), brings up the cost of fettling to the point where sometimes the production cost overtakes that of selling.

In the study of steel moulding sands it is therefore of paramount necessity to recognise that the hard-rammed facing sands gradually lose their physical character, though not necessarily their chemical composition, through repeated using.

These may be renewed by the addition of new coarse material, after the fines are sieved away, and used as backing, though the addition of pore-making material such as saw-dust and coke in the backing may be overdone and lead to abnormal expansion when drying the mould. Every steel-founder knows the importance of the open, porous and elastic backing which is needed between opposing projections, the contraction between which where the mould is too resistant, leads to skin fracture.

The face washes are of vital importance, and whether they are partially volatile, as in tar washes or graphite, or highly refractory as in silica paints, there is need for great care in applying these in such a way as to effectively penetrate the skin surfaces of the moulding composition. The wash should expand and contract with the sand, or "peeling" is inevitable.

Researches on moulding sands for steel castings require to be of such a nature as to include compositions suitable for small as well as large, thick as well as thin castings; they should include the characteristics needed for core sands as influenced by slow or quick drying and cooling. The influence of runner-stream erosion on flat and broken surfaces and the problem of tough yet elastic surface facings for resisting contractional "nip" between collars or flanges should be tackled. The conclusion one must arrive at is that the research ground is the foundry and not the laboratory, though the chemistry and micrography must not be neglected. Observations can only be made use of in their application to commercial objects.

The vital problem of the proper use of used material and the "doctoring" of repeatedly used sands for various specific purposes, as backing, facing or core material, alters with the type and weight of the castings required. Hence it must become necessary to organise methods for regularising the disposition and circulation of new and used sands and to make mould and core drying a much more scientific operation than it is often allowed to be.

Most foundries are rushed to death, and the accidents due to over or under stoving, repaired moulds after drawing badly-made patterns, careless swab washing and sleeking, poorly-fitting or badly-constructed moulding boxes, together with the often disastrous results of the concussion of moulds when setting for teeming, accounts for many of the defects which give steel castings a bad name and which sometimes only appear when a casting, after annealing and dressing, is passing through a final costly machining operation.

A most unfortunate and outstanding fact is that steel castings are ordered in comparatively small quantities from any specific pattern, hence the "jobbing" nature of the work in most steel foundries. This succession of "odds and ends" gives but little chance for specialisation in moulding-box design, sand preparation, drying and casting arrangements, etc. In foundries dealing with large work, scarcely two castings are alike, each having to be considered separately, and probably this is inevitable.

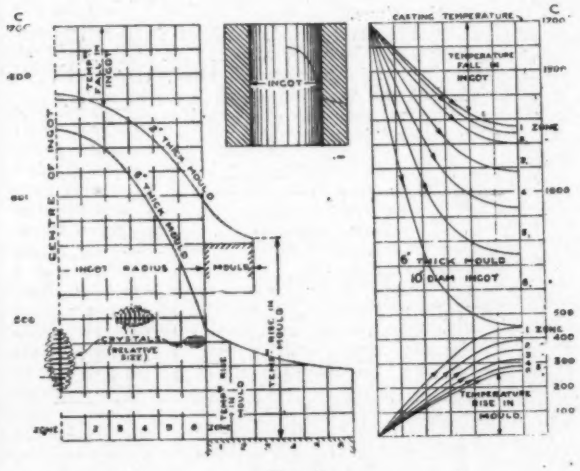


FIG. 3.

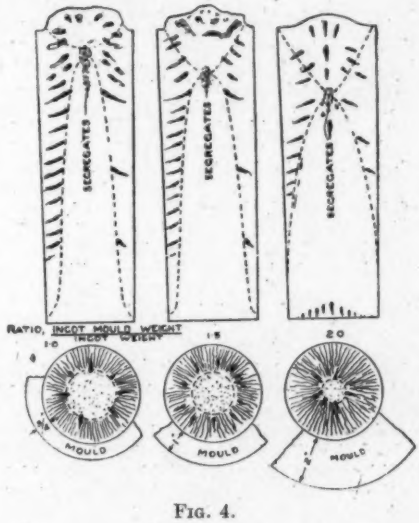


FIG. 4.

It is in the case of small castings, however, where repetition work calls for special treatment and where, given suitable design, it must be possible to ensure perfect results. Unfortunately, the competition for large quantities of castings from the same pattern has often led to selling prices so low that rushed work has been the rule.

The natural commercial instinct is to produce the greatest weight possible per square foot of moulding ground, and per pound sterling of invested capital and of running costs. This ideal is not always conducive to the production of perfect castings, which often require for their manufacture expensive moulding tackle, sands and compositions, carefully melted steel incurring higher melting and raw material charges, a more highly trained and well paid staff, and often more costly moulding and finishing labour.

One of the chief points which the author is desirous of emphasising in the present paper is to draw attention more particularly to a few details connected with the effect of cooling of castings

from the molten state, and to show by a few typical cases the influence of design on the surface and internal structure of steel castings.

The fundamental fact to be recognised in the freezing of molten iron or steel is that from 95 to 99½ per cent. of this congealing metal consists of iron. This iron tends to solidify as dendrites or fire-tree-like crystallites. The more slowly the cooling is effected the larger or coarser these crystallites are. They form first at the cool surfaces of the moulds in which the liquid is poured and the axes of the dendrites are primarily normal to these cooling surfaces. These axial directions would persist until the crystallites growing from the opposite mould surfaces met, were there not certain opposing influences. First, there is the fact that all molten iron and steel contains gases in solution. Each crystallite ejects its occluded gas into the surrounding liquid metal, which is thereby rendered lighter. The horizontal dendrites, therefore, whose ends may be compactly frozen together at the mould surface tend to droop as they reach inwards towards the axis of the ingot, and may break off near the drooping point and float off in any direction within the liquid centre zone. These dendrites of fir-tree-like crystals freeze rapidly at the mould surface where their trunks and spines are not so robust as they become later when, thrusting forward into the molten liquid, they grow more rapidly. No doubt convection currents within the liquid metal play a part in breaking off the dendrites before they attain maximum length. The outer envelope of frozen metal, therefore, consists largely of dendrites whose axes are fairly normal to the mould or chill surfaces. Beyond this outer zone a position is reached where the crystallies droop and fracture, and from this point to the casting centre the dendrites have their axes in confused orientation. When carbon is present, in the absence of the graphite - liberating constituents, silicon, nickel or aluminium, the freezing of the carbide-of-iron crystals in the mother liquor which surrounds the iron dendrites (and it should be remembered that these crystals freeze very rapidly) drives the liberated gases sharply towards the liquid centre. Any metalloid present which tends to the retention of carbon in the combined state, such as manganese and chromium, promotes rapid freezing of the envelope at the mould surface, and yields a thick skin of fine crystals whose axes are frozen at right angles to the mould surfaces. On the other hand, silicon, aluminium and nickel impede the formation of the carbide crystals and facilitate the iron-dendrite growth and the coarser structure associated with slower cooling, and the more gradual release of the occluded gases. As an illustration of the above-mentioned phenomena, and of the effect of different rates of cooling on a nickel-chrome steel cast in moulds 1, 1½ and 2 times the weight of the ingot, Fig. 4 is given. The escape of the occluded gases is clearly influenced by the rate of freezing.

The rate of cooling of a casting in a metal or sand mould is interesting to follow, and the effect of differing thickness of mould relatively to the thickness of steel cooled therein is a matter of importance. Taking first an ingot cast in a chill or cast-iron mould, it will be seen that the relative fall in temperature of the ingot and the corresponding rise in the temperature of the mould vary according to the ratio of mass of mould to that of the ingot. Thus, it was calculated that an ingot cast in a mould of cast-iron having the same weight as the ingot dropped in temperature 920 deg. C., whilst the mould temperature rose 780 deg. C. In a mould having twice the weight of the ingot the temperature drop in the ingot is about 1,200 deg. C., during a temperature rise in the mould of 510 deg. C.

Again, in the case of sand moulds, a 10-in. diameter ingot had a thickness of sand mould of of 10 ins., the weight of sand being twice that of the steel. The temperature drop in the ingot was found to be about 1,420 deg. C., the mould mean temperature rising 280 deg. C. With a sand mould thickness of 16.3 ins. surrounding a 10-in. ingot, the temperature fall in the ingot was estimated to be 1,565 deg. C., whilst the mean rise in the mould was 135 deg. C., the initial temperature of the steel being taken at 1,700 deg. C.

Table I. has been prepared to illustrate how mass of mould affects the rate of ingot cooling and, further, to show how the rate of cooling varies throughout the thickness of a steel casting, and how the mould correspondingly rises in temperature. Figs. 2 and 3 have been plotted from careful estimations.

It is difficult to state without further experiment what is the exact rate of heat travel, say, in inches per minute through steel, cast-iron and sand, but the diagrams do indicate in a very interesting manner the comparative cooling action of sand and iron moulds.

TABLE I.

Ratio Weight mould. / Weight ingot.	Ingot diam.	Thickness mould.	Ratio $\frac{F}{R}$	Common Temp. C.	Approx. time cooling.
Iron mould.	Ins.	Ins.			Min.
1.0	10	2.25	1.17	830	31
1.5	10	3.10	1.76	663	23
2.0	10	3.90	2.35	557	19
3.0	10	5.30	3.52	425	14
4.0	10	6.50	4.69	356	11
8.0	10	9.75	9.38	213	6
Sand mould.					
1.0	10	6.50	2.73	504	225
1.5	10	8.65	4.09	383	160
2.0	10	10.50	5.46	313	130
3.0	10	13.60	8.18	235	92
4.0	10	16.30	10.92	185	67
8.0	10	24.75	21.84	124	37
16.0	10	36.75	43.68	88	19

In ratio F/R F is fall in temperature (mean) of ingot; R is rise n temperature (mean) of mould.

The effect of a thick chill or metal mould emphasises the cooling action on the zones of the ingot nearest to the mould, where the temperature gradient (fall) is greatest. The points brought out by the estimations are that when the thickness of the metal mould exceeds that of the casting, any further mould thickness does not greatly influence the rate of cooling action. From Lord Kelvin's data the diffusivity of heat in iron is from 15 to 20 times that of sand, hence the speed of cooling of a casting in an iron mould is, say, 15 times greater than in a sand mould. An ingot, therefore, which falls in temperature from 1,500 deg. C. to 550 deg. C. (mean) in an iron mould in 20 minutes will cool down to the same temperature in a sand mould in from 6 to 7 hours. In such a case the estimations have been made on 10-in. diameter ingots cast in iron moulds 4 ins. thick and in sand moulds 10 ins. thick.

The curves in Fig. 2 indicate the fact that the effect of increasing the mould thickness in chilling or cooling the steel casting is greatest when the ratio of thickness of mould to that of casting is below 0.25 in cast-iron moulds and below 1.0 in sand moulds. In the latter the rate of cooling diminishes progressively as the thickness of the sand mould exceeds twice that of the steel casting. When the sand mould thickness exceeds eight times that of the casting further chilling action of the sand is nil.

The practical use of the above investigation is obvious. It can be proved therefrom that a cast-iron chill half the weight of the steel ingot cast in it cannot stand, the temperature of the inner surface reaching the melting point of cast-iron. Similarly, a sand mould only 1 in. thick surrounding a 10-in. diameter casting would not conduct away the heat sufficiently rapidly to prevent the surface of the mould attaining a temperature of, say, 1,330 deg. C., at which temperature it would probably soften or fuse, unless the sand were backed

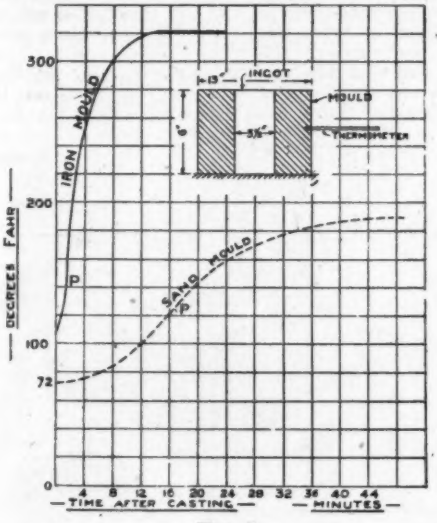


FIG. 5.

up by material such as cast-iron which would conduct the heat away more rapidly than the sand, as is generally the case in practice. The case is, however, sometimes met with when only a thin strip of sand divides two heavy portions of a casting.

In very early Sheffield ingot practice the advantages of the rapid conduction of heat away from the mould were recognised, and for years, ending with a disastrous explosion, water-cooled moulds were used. The rapid chilling of the steel castings surface is illustrated by the steep temperature gradient in Fig. 3. Its effect is to produce fine crystallisation, the iron, or more correctly the austenitic dendrites, being small and densely packed together at and normally to the mould surface, the inner and slower-cooling zones producing larger dendrites. Figs. 6 and 7, from cast-iron chill-made castings, show outer and inner dendritic forms, and are quite representative of similar crystallites in steel.

Quite recently Mr. Ashdown has returned to the water-chilling of moulds, by casting water-pipes within the mould-walls through which the cooling water is made to circulate. The author had experience in the use of water-cooling in the Harmet fluid steel compression process, where the very thick moulds were further quickened in their cooling action by spraying water over the exteriors. A very fine crystalline structure of the outer envelope of the ingot resulted, and indeed generally a finer crystallisation was obtained, to the benefit of the forgings later.

A close study of the above matter will quickly show that the rate of cooling of a casting having thick and thin sections may be dangerously different in these different sections of the same casting. The outer and rapidly freezing envelope may be passing the temperature zone of recalescence with its accompanying dilatation whilst the inner are only just freezing. In the case of castings having a higher manganese content than 1.0 per cent., with silicon under 0.20 per cent., the dilatation of the steel when passing 700 C. is severe and may readily burst or tear the skin. Here the austenitic passes to the pearlitic state abruptly, the more so as the carbon content is high. There is a limiting ingot-mould thickness for ensuring freedom from skin cracking, though this latter is influenced by rate of pouring and other questions. This thickness bears a fixed ratio to the ingot diameter, and it will be seen that the length of the ingot is also connected with the skin-bursting pressure.

The first rapidly frozen envelope shrinks away from the ingot mould. The liquid steel contained within the vase has a pressure heavy enough to burst the skin, and in the early moments of the ingot's life these skin fissures allow liquid steel to exude and become frozen at the mould face. If the mould is not massive enough this skin fissuring produces a very rough surface in the ingot and often a kind of " cold shut " occurs which is aggravated when the mould sides have been splashed badly by too quick and drastic pouring, such as leads to tearing when the ingot is forged or rolled. It was computed that in a 20-in. ingot 6 ft. long just frozen, the envelope being taken as one-tenth of an inch thick, the bursting pressure on the wall of the freezing envelope near the bottom of the ingot is about 20 lbs. per square inch. The tensile stress resisting the liquid pressure would be about one ton per square inch of section of the envelope, which at white heat would readily burst or tear. The sharp corners of a square or polygonal ingot, freezing more rapidly than the sides, yield a stronger envelope, hence tearing is more or less avoided, provided the mould is thick enough. The weakness of a cylindrical chill mould is thus explained, and the effectiveness of ingots cast with the small end downwards and poured slowly is evident, compared with taper ingots cast in moulds having the large end at the bottom.

In sand moulds the skin fracture under high pressure head, especially in massive castings, is readily detected. Here the envelope cools slowly and is very thin for a considerable time after casting in many cases. The fissures are, however, rapidly healed though certain " worm marks " on the surface tell the history of the early moments of freezing, skin fissuring and healing. Very often the fissure is the outlet for escaping gases which leave with the exuded metal, the smooth marks of the gas streams being often plainly visible. It is not unusual for the worm marks to finish at a small shrink-hole communicating with an inner cavity. Pickling in strong acid will often open up hidden blow-holes or pipes and hair cracks running along the worm tracks, the old fissure lines. Such

marks are as a rule associated with heavy castings and are affected by too rapid pouring and high temperature of steel, especially where the mould thickness is too small.

In multiple castings in one mould it is not unusual to trace defects due to the ignoring of the slow rate of cooling of closely grouped heavy parts. For instance, a group of four projectiles cast vertically in a cluster and run through a central runner was attempted. Too small a thickness of sand was allowed between the inner surfaces of the castings, hence these parts cooled most slowly; were more coarsely crystalline and in many cases became badly honeycombed, the receptacles of slaggy particles and occluded gases. Sand adhered to these inner surfaces because the temperature of the sand there reached its fusion point.

The difficulties experienced with thin cores in heavy castings can only be overcome by freezing the metal in their immediate neighbourhood by introducing some chilling media such as wire nails or clothing plates. In one case water-cooled pipes constituted the core through a heavy casting—a risky procedure.

In the study of rapid chilling the author found that Harmet quickly-frozen and compressed steel ingots were denser than ordinary chill-cast ingots, the increase in density being closely proportional to the volume of the pipe in an uncompressed ingot of similar total weight. Again, an ingot was cast with a central metal solid core, in a thick chill iron mould. The metal on freezing did not nip the central metal core, which was easily withdrawn. In such a case the author found it possible to so apportion the mould to the core diameter as to ensure an absence of contractional nip on the core. The withdrawn chill core is then smaller in diameter than the hole in the ingot centre.

If the phenomenon of contraction is due simply to crystalline shrinkage, then in the above case the ingot should have nipped the central bar core. The author has for years contended that the occluded gases in steel are inseparably connected with the phenomenon of contraction, and by assuming that such is the fact has, by designing cast-steel forms with the direct object of securing uniform cooling and correct feeding (i.e., displacing the occluded gases by liquid metal in such a manner as to avoid premature freezing of gas pipes or cavities) overcome many of the usual contractional difficulties.

A very instructive series of tests was carried out with the purpose of finding the relative heat transmission of fine and coarse moulding sands per unit of time. A heating plate was uniformly raised in temperature by electrical means, a 6-in. diameter hoop 2 in. deep being filled with the sand, resting directly on the heated plate. The bulb of a thermometer dipped ½ in. into the sand and readings were taken every minute during a temperature rise of from 80 deg. F. to 200 deg. F. It was found that the rate of heat conduction up to about 150 deg. F. was the same for both fine and coarse sands. Beyond 150 deg. F. the rate of conduction was much higher in the case of the fine sand, 200 deg. F. being reached in 44 minutes in the case of the fine as against 59 minutes with the rough sand, these tests being carried out on moderately damp sands of usual moulding consistency or perhaps slightly drier. When the sand is dry the rate of heat conduction is much more rapid in the fine sand than in the coarse, being about twice as rapid between temperatures of 80 deg. and 150 deg. F. At about 180 deg. F. the conduction rate slows down somewhat, rising again at from 200 deg. F. to 220 deg. F., above which temperature the heat conduction rates for both fine and coarse sands are not greatly different, though the fine always has a higher conductivity than the rougher sand. Mixtures of fine and coarse sands conduct heat more rapidly than fine sands—they are more closely packed—hence a larger area of contact between the particles, and the average interstitial spaces are smaller than in the case of either fine or rough sands separately used.

A further comparative test of heat diffusion through sand and cast-iron moulds is given in Table 2. In each case the mould was 13 in. outside diameter and 5½ in bore, 6 in. deep. Cast-iron at about 1,240 deg. C. was poured into the mould and the temperature was taken at a point half-way down the mould half-an-inch below the outer surface of the mould. The temperature fell to 160 deg. C. in the iron mould in 14 minutes; in the sand mould (green sand skin-dried) the temperature dropped to 87 deg. C. in 45 minutes.

The heating curves are shown in Fig. 5, and indicate the fact that during the first few minutes (two minutes in the case of the iron mould and 14 minutes for the sand mould) the rate of heat conduction is slower than later. This appears to correspond with the period of freezing, for contraction was not visible until these points (marked P on the diagram, Fig. 5) were just passed.

TABLE II.

Minutes after casting	Mould temperature Fahr.	
	Iron.	Sand.
	Deg.	Deg.
0	102	72
1	120	74
2	174	76
3	218	—
4	242	78
8	302	82
10	312	90
12	317	99
14	319	110
16	320	121
20	—	141
25	—	159
30	—	174
35	—	182
40	—	187
45	—	191
50	—	191

The points already raised are really of vital importance to the scientific study of steel casting design, and lead us to the conclusion that the envelopes or skin zones of castings are the locale of those initial contractional stresses which if not duly provided for inevitably lead to trouble. Through these zones the quick temperature gradients occur; they are the equivalent of the cooling surfaces of a condenser tube of a refrigerator. These rapid temperature gradients, varying in value at different points in the casting skin, are associated with corresponding differences in contraction. In steel, as in cast-iron, there are two different types of crystals which together make up the structure. First, the dendritic primary crystals which are the first to solidify, and secondly, the more highly carburised crystals freezing later. Each form of crystal cools at a different rate and has a correspondingly different contraction.

In the designing of castings, therefore, it is necessary to remember the contractional differences in the two kinds of crystals which together make up the metallic mass. Ledebur years ago pointed to the fracture during cooling of the eutectic plates

in white iron, and it is most instructive to examine the structures of such irons when quenched from the liquid state, the microscope revealing plainly the difference in the rate of contraction and the fracture so common in the carbide portions. The spontaneous fracture of castings along the weak planes of crystalline separation at sharp inside corners is due to the same cause. The rapid surface chill freezes the composite metal there, the soft iron crystals growing at a different rate to that of the more highly carburised mother liquor and contracting at a different rate. When the voids left by contraction and the escape of the occluded gases at the hot mass centre of a casting are not filled up by the fluid feeding metal shrinkage cavities are inevitable.

It is obviously the duty of the designer to see that there are no local heavy masses which can act as a receptacle for occluded gases from adjacent thinner and more rapidly cooling areas, and which are so placed as to be incapable of being fed. The shape of the cavities or liquid-contraction holes in such badly fed masses is often such as to promote

FIG. 6.—FROM BOTTOM OF LARGE CASTING TEST-PIECE; BADLY ANNEALED, BECAUSE TOUCHING FURNACE FLOOR DURING ANNEALING. MAG. × 100 DIA.

serious incipient cracks. When occurring in the upper portions of castings they are most serious, for there the liquid metal pressure head is least. Whistlers or vent risers placed at such points, though sometimes successful in partially releasing the gases, are often dangerous because, freezing before all the gas is liberated, a pipe hole or gas path may finally remain, leading from the outside of the casting to the centre of the mass.

Difference of liquid pressure head at the various parts of a large casting brings about varying rates of crystallisation and of contraction. High pressure head induces more rapid crystal growth and of finer character than does a lower pressure. The recalescence is reduced in intensity by pressure and, as in the case of refractory materials heated under pressure, there is much to support the view that the freezing point is lowered thereby.

All this points to the value of long feeding heads wherever possible of not too small a cross section as to quickly freeze the feeding metal; the gas escape is promoted in the correct direction, *i.e.*, towards the feeder heads, and the rate of contraction is lowered, all to the advantage of the casting.

It is important to remember that contraction proceeds towards the heavy mass centres of a casting, towards the metal which is the last to solidify, and hence generally towards the feeding points and rising heads. In casting a number of long steel pump-rods horizontally the total contraction was over 10 in., the rods being 45 ft. long. The feeding head was placed at one end where the metal was bulkiest, the casting being run through a comparatively small git or runner from the opposite end, hot metal being used for feeding at the heavy end. The small running git being released soon after casting, there was little resistance to free contraction. It was found that the casting contracted almost entirely in the direction of the feeding head.

This example is typical and illustrates the fact that feeding points are the centres towards which the remaining parts of a casting contract. Such gases as can escape through the liquid metal mass during freezing find their way to the feeding heads.

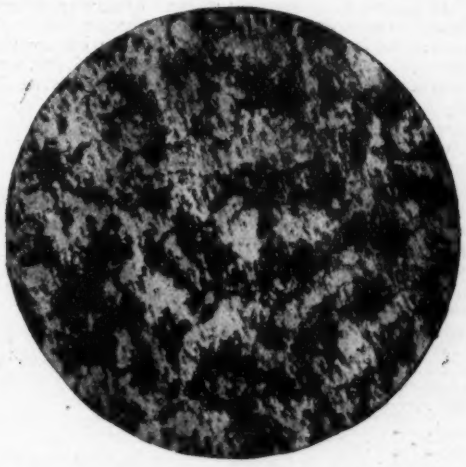


FIG. 7.—SHOWING INFLUENCE OF IMPRISONED SLAG PARTICLES IN CASTINGS. MAG. × 100 DIA.

If they cannot get there they are trapped on their way and become danger points. Wherever two heavy parts of a casting are united by a thin section the heavy sections attempt to do duty as feeders and often act as receptacles for the occluded gases; the quick freezing of the thin connecting section may lead to contraction tears at the points of junction with the heavy section, pulling taking place whilst the heavy masses are still molten or semi-solid. In grey cast iron the effect of such false feeding is often seen as a spongy area in which coarse graphitic flakes are plainly evident. Such conditions exactly favour the growth of graphite, for wherever a heavy mass under a low fluid pressure head is isolated from the feeding points by a thin rapidly-cooling section it acts as a feeder to such section and as a reservoir for the gases thrown out of solution during freezing. The cavity formed is analogous to the drusy cavities in many mineral veins the sides of which are found to solidify from the gas-charged molten magma. In such gas cavities in grey iron the decomposed

iron carbide separates out slowly as coarse graphite.

The surface skin or envelope of a casting is the locale of most contractional troubles, and, in remembering that the primary crystals always freeze at right angles, or approximately so, to these surfaces, it will be seen that it is in securing that the two types of crystals are closely interlocked and never torn apart that success in casting is attained. The surface of a casting is always in tension during the contraction which accompanies freezing and cooling, except during the dilatation or expansion which occurs during the early freezing period of grey cast-iron. It is possible that the crystalline cohesion between the skin crystals is not so great across their axes as in the direction parallel to the axes. Entrapped gases, sulphide films and globules, graphite flakes and slag inclusions, to say nothing of the accidental fused particles of facing washes, etc., must play their part in separating the crystals and in weakening their resistance to tensional or contractional stresses acting at right angles to their axes, in directions parallel to the mould surfaces.

It is clear that the skin crystals conduct the heat from the interior to the mould surfaces along their axes, and it is instructive to consider closely the effect of cooling in the various types of surfaces common to castings. Assuming that unit area of mould or chill surface cools the adjacent metal in contact therewith to unit depth in unit time, the following interesting figures have been arrived at :—

	Cooling surface per cubic unit cooled.
1. Flat plate surface	1.00
2. Internal angle, 90°	0.67
3. External angle, 90°	1.33
4. Internal solid angle, 90°, three planes intersecting	0.43
5. External ditto., 90°	1.14
6. Internal spherical surface of small radius	0.37
7. External ditto	0.75

These figures, though only approximate, yield an index to the depth of the chill crystals and are roughly an indication of the degree of fineness of the crystalline structure at the mould surfaces. Thus, supposing a chill throws one inch depth of carbide crystals at the face of a flat plate, the depth of chill crystal at the corner of an internal solid angle formed at the intersection of three planes in similar metal would be only .43 in.

This means that the freezing is rapid on the three flat surfaces surrounding the contained solid angle, but that it is slow around the apex of the solid angle. Fine crystals with great resistance to contractional tearing are formed in the first case, coarser crystals with less cohesion in the second case. This explains why it is that at such solid internal angles the apex is so often porous, not infrequently leading to small gas cavities, the slowly cooling liquid metal there acting as a receptacle for the gases ejected from the surrounding rapidly freezing crystals. A considerable radius is obviously necessary before the corner can freeze to the depth of the adjacent plates.

The rate of contraction in any part of a casting is determined by the amount of cooling surface presented to each cubic unit of metal. The specific heat of cast-iron, steel, and of moulding sands and compositions, at high temperatures of 800 deg. C. and over, is not yet definitely known, but the specific heat of moulding sand is quite twice that of cast-iron or steel. The rate of heat conduction per square inch of sand surface is from 1-10th to 1-25th that of steel or cast-iron, whilst that of air or CO or CO_2 gas may be taken at one-third to half of same. It is clear, therefore, that during the time the metal is in contact with the mould surface the cooling action is relatively slow. As the metal freezes and contracts away from the mould sides the air-gap action speeds up the cooling action. Local clots of dampness due to accident at the mould surface rob the casting of heat rapidly at such points and lead to prematurely frozen spots, sudden formation of steam, disintegration of the mould surface, scabs and surface tears.

It is quite impossible to touch the question of designing castings save in the most cursory fashion, the myriad forms of such making it necessary to only briefly state the dominant types. The following may be taken as representative :—

(1) Hollow cylindrical forms, thin or thick, long or short relative to the diameter, ribbed, flanged, of constant or varying diameter or thickness.
(2) Plate-like forms, of uniform or varying thickness, plain, ribbed or flanged.
(3) Box forms, with flat or curved sides, internally or externally ribbed or plain.
(4) Combinations of (1), (2), and (3).
(5) Wheels, rims or hoops, with or without arms, with plain or toothed peripheries, with light or heavy centre bosses.
(6) Discs of uniform or varying thickness, thin rims and heavy bosses, heavy rims and light bosses. Thin or heavy webs, ribbed, plain or perforated.

The old and well-tried advice that sharp corners should be avoided and that the thickness of castings of intricate form should be as uniform as possible must always stand good. Designs which embody these defects are impossible, but there are many other considerations to be borne in mind. A pattern may be so made that the mould may be wrongly constructed from the point of view of contraction, gas escape, or the proper placing of the

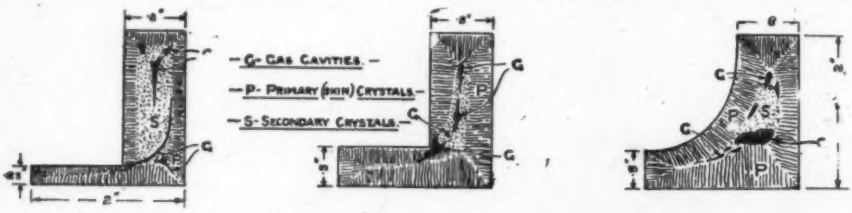


Fig. 8.—Sections of Castings made in Slag (Cast in Sand Moulds) from Puddling Furnace; Showing Influence of Thickness of Casting on Crystallisation and Gas Escape. All Bars were 6 in. long.

casting heads or gits. How many poorly-made patterns have to be sledge-hammer rapped before they will draw? Many defects are due to high-velocity casting streams directly impinging on the bottoms of direct-run moulds from deep ladles. The value of efficient means for breaking the stream velocity and of correct teeming rates is more important in the case of castings than in that of ingots, which point Mr. Kilby so well brought out in his recent Paper on steel ingot defects. If the heavy portions of a casting are adjacent to thin ones, and there is no possibility of feeding the heavy sections save through the thin ones, pulls or tears and internal cavities are inevitable. Many castings are so designed that there is no chance of placing efficient casting or feeding heads in the position imperative for the proper feeding of heavy sections. Some of the simplest forms have given the greatest trouble, large discs, for example, with heavy rims and thin webs.

In many cases the study of the cooling rate values at the different portions of a casting will at once point out the possibility or otherwise of a design. In a word, the designer should know the laws governing the flow of liquid metals, how to make the pattern, and have much more than a causual acquaintance with the moulding art.

It is not fair to expect the steel founder to produce castings of doubtful design successfully, though he is often at the tender mercy of such caprice from one year's end to another. In these days of intricate machinery the steel founder is constantly experimenting, at great cost, with new and untried designs, often with serious losses in wasters, whose defects are only discovered in final machining operations.

In the manufacture of very thin castings the fluidity of the steel is obviously of first importance. It is not the function of this paper to discuss the relative efficiency of the different forms of melting furnaces, but it is clear that the electric furnace is specially fitted for the making of hot and fluid steel. It is essentially a scrap-melting furnace, and the material produced is in the same category as cast-iron which has been twice or thrice melted. It is more gas and slag free and lower in sulphur than steel melted generally by other processes. It is quite true that hot steel can be produced by the Tropenas, Stock and open-hearth methods, but from the very nature of things, the open-hearth or air-blown processes, using pig-iron as the basis and air or ore as the refining media, give a metal which is liable to gas occlusion and slaggy particles.

Now, gassy fluids travel viscously in thin passages of the moulds, the surfaces of which strongly chill the metal as it flows. Conceive the running of a thin cylinder of large diameter and of considerable length cast vertically and run from the bottom. As the steel flows and rises in the mould, the skin is frozen almost instantly. The succeeding metal has to rise through the envelope which is conceivably repeatedly broken and as often rewelded, the semi-plastic crystals of the envelope mixing with the ascending stream. If the mould surface is not smooth and good, particles of sand facing must flow with the disintegrated skin crystals and help to make the rising stream more and more viscous. If the steel contains much occluded gas it is easy to see that the ascending steel must become increasingly porous and perhaps effervescent. It is in the minimising of these inseparable difficulties that electrically melted steel scores.

Again, one must point out that the ratio of cooling surface to the thickness of the adjacent metal is important—indeed, all important in the case of thin castings, as is the supply of hot, gas-free steel. No doubt thin, sound castings have been produced having a cooling ratio of 2/¼ or 8 sq. in. of cooling surface per cubic inch of adjacent steel, in small castings of a few pounds' weight. Such a ratio is, however, impossible in larger castings.

There is a limit to the distance such thin streams can travel without becoming viscous, sluggish and gassy. This depends on whether the path is direct or tortuous. Where a thin stream has to pass through a quick change of section, say a heavy rib or boss has to be traversed, and emerge therefrom into a thin section again, the stream velocity is checked at the heavy section and the possibilities are against the remoter thin sections being solidly filled.

The annealing of steel castings is a subject worthy of more time than is now available. Suffice it to say that the proper temperatures are now well understood, the upper soaking point varying slightly with the carbon content and considerably when alloy steel castings have to be treated. The mixture of large and small pieces in the same furnace leads to heavy scaling of the smaller castings which, in the case of mild steel electrical castings, need only a reheating beyond the normalising temperature of, say, 850 deg. to 900 deg. C.

Heavy castings are liable to under-annealing at the portions touching or near to the furnace floor, whilst the upper portions may be scorched. Mysterious failures of tests taken from such floor-contact positions were not unknown years ago, and occasionally happen to-day. A diagram showing the rate of heating and cooling of the inside and outer portions of a heavy casting (20 tons) illustrates the influence of mass and of floor contact.

Each type of casting presents its peculiar difficulty, but it is hoped that the matter brought forward in the lecture will draw special attention to the fact that the skin of the casting is a vital detail, and is of such important crystalline structure that it very often controls the practical strength of the machine part so cast. A further attempt has been made to show that the gases released from the metal crystals as they freeze play an important part in the phenomenon of contraction, as would appear to be proved by the fact that castings contract towards the feeding heads or towards local mass centres which become virtually feeders, and which, when cold, are found to be hollow and gas filled. It has also been urged that the two types of skin crystals are principally governed by the silicon and total carbon content of the metal, be it steel or cast iron, manganese promoting hard and rapidly contracting envelopes, whilst silicon promotes soft ferritic surfaces of slow contracting properties. Only a few hints have been hazarded in this direction; it is a line along which the writer has travelled some distance, with a view to correlating the influence of the metalloids with gas occlusion, skin stresses, and contraction.

Draw and shrink holes, pulls, gas cavities are all related and are influenced by the efficiency of feeding heads. It has also been shown that liquid pressure is a factor in crystalline structure, surface strength and contraction, and is of extreme

importance in obtaining really effective feeding. To attempt to illustrate further by means of concrete examples is fascinating, but impossible in the time at the lecturer's disposal. He hopes, however, that some of the principles described will be useful in encouraging such design of castings as shall ensure non-stressed envelopes, a possibility of applying feeding heads of ample size and in correct positions, and such a disposition of the surface as shall not tend to early crystalline rupture or separation. On the part of the moulder, he must see that the rigidity of his moulding material is not too great, so that, without too drastic baring or releasing of a semi-frozen metal, there is a yieldability or collapsibility of core and mould alike, so that the tender skin crystals which later are so vital to the value of the casting are allowed to grow and interlock without undue resistance. The outer skin of a casting is often deceptive as an indication of the actual condition of things just below that skin. The film of oxide, or graphitic or silicious face-wash, covers very often a mass of minute blowholes which are revealed by such drastic cleansers as the sandblast or the pickling bath. The pickling of steel castings previous to galvanising is often a revealer of the defects of design of moulding and of casting; the shrinkages under sharp corners, the worm-hole paths leading from the surface to hidden gas cavities and to badly fed centres below.

Not all these defects are due to occluded gases, being sometimes the result of damp moulds, the steam generated therefrom in trapped corners leading to a steam penetration of the casting skin, especially at such a point as the apex of the external angle of the intersecting planes, which is often in a molten state when the surrounding plates are frozen.

By concentration of thought on the points brought forward in this paper the author hopes that some help to the founder in his interesting trade, and the designer in these days of intricate machine parts, may result.

(Discussion on this paper will appear in our next issue.)

Effect of Mass on Heat Treatment.*

By E. F. Law, Assoc.R.S.M. (Manchester).

The author points out that the heat treatment of large masses of steel presents many difficulties which do not exist in the case of small masses. The difficulties lie, not in the lack of knowledge concerning the properties of the steel, but rather in the practical application of that knowledge. In order to obtain some information concerning the changes taking place in the interior of a mass of steel during treatment a series of experiments were carried out, and the results are published in the Paper. Large diagrams show the cooling curves obtained from the heat treatment of 18-in. cubes of steel cut from a 25-in. ingot 10 ft. long. The author describes the method of procedure adopted in the experiments, and comments on the curves. Perhaps the most noticeable feature about these curves is the rapidity with which the heat penetrates to the centre of the cube. At 130 minutes from the time of charging, the centre and half-way are almost at the same temperature; but at this point the absorption of heat due to the Ac change causes a greater lag at the centre than elsewhere, and the two temperatures do not approach one another again till the lapse of another seventy minutes. A period of about 4½ hours was required for the cubes to attain a uniform temperature throughout their mass, coinciding with the temperature of the furnace.

As regards mechanical tests, from each of the experimental cubes, after cooling, a section 1 in. thick was cut through the centre, and from this section thirteen test-pieces were machined, so that mechanical tests could be taken representing the steel from outside to centre of the cube. The results are plotted in diagrams, and, as might have been expected, the thirteen results from the air-cooled cube gave practically identical results. In the case of the oil-quenched cube the breaking stress and yield are both raised, while the elongation is lowered, to almost the same extent in every test, the curves approaching a straight line. In other words, the effect of oil-quenching is as apparent in the centre of the cube as on the outside. In contrast to the results obtained by oil-quenching, those obtained by water-quenching show a very decided variation from surface to centre of the cube; and this is most marked in the case of the cube plunged in cold water. The effect of the quenching is uneven, and the tests suffer from the lack of what might almost be described as "automatic tempering," which occurs in the lower ranges of temperature during oil-quenching. An abrupt halt in the neighbourhood of 250 deg. Fah. (120 deg. C.) shown in the curves obtained from the water-cooled samples the author describes as totally unexpected, and he discusses whether the break in the curve is due to some change taking place in the steel itself, or is in some way connected with the water used in quenching. The latter explanation was not supported by the facts. Experiments repeated on 18-in. and 12-in. cubes showed that, whatever the cause of the phenomenon, it occurred with remarkable regularity, and was not affected by reasonable variations in mass. Attempts were also made to locate the point during oil-quenching, and in spite of the slow rate of cooling through this range of temperature, there was distinct evidence of its existence. It appeared, therefore, that the phenomenon was in some way connected with the steel itself, and, even at the risk of evolving yet another theory of hardening, it was decided to investigate further.

For this purpose the large cubes used in the earlier experiments were abandoned, and 2-in. cubes substituted, as they could be more readily handled and the experimental work could be transferred to the laboratory. Naturally, the accelerated rate of cooling of the small cubes altered the conditions of the experiments, and it was now found that the break in the curve at 120 deg. C. was very noticeable in the oil-hardening, whereas in the water-quenched cube no break was observed. Further, the water-quenched cube was too hard to machine, and, after grinding and polishing, was found to possess a martensitic structure. The oil-quenched cube, on the other hand, was readily machined, and possessed a pearlitic structure.

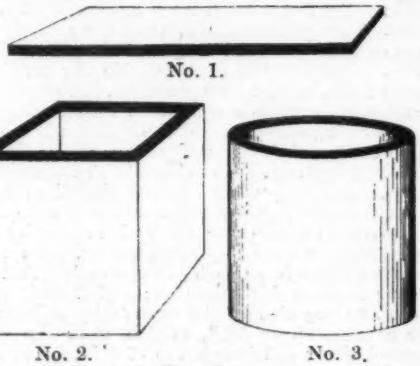
Repeated experiments on quenching at different rates showed that whatever the rate of cooling through the higher ranges of temperature down to 300 deg. C. no appreciable hardening effect was obtained. It was only when the rapid cooling was continued through the lower ranges of temperature that the hardening was effective.

* Abstract of Paper, read before the Iron and Steel Institute, May, 1918.

Contraction and Expansion.*

By G. W. Lynes.

This subject is peculiarly the moulders' own, involving one of the basic principles upon which the superstructure of success is to be reared; but if one were to challenge the average moulder upon the matter he would deny all responsibility. Contraction and expansion as affecting the pattern-maker present a simple problem which he can determine with almost mathematical precision, whilst the same problem as it affects the moulder



No. 1. No. 2. No. 3.

FIG. 1.

becomes at once abstruse and complex in the extreme. Certain facts in connection with metal shrinkage should be common knowledge to every moulder. There are two kinds of shrinkage in the making of a casting. The first and far the greatest is that which is termed internal shrinkage—the resultant of the differences in the specific gravity of the molten metal and the specific gravity of the solid metal. In white iron this is very considerable, and must be allowed for in the heads and feeders placed upon the job. The mould capacity requires as much solid metal as at first there is molten metal, and the difference in the specific gravity may reach as much as 8 or 9 per cent.; so it can be readily seen how important a factor is the feeding of a big job. To obtain a solid casting, free from internal fracture and sponginess, sound judgment and great discrimination are needed in making provision for it by the

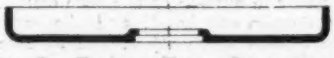


FIG. 2.—CONNING TOWER ROOF PLATE.

use of heads, not so much in regard to bulk (though that is important) but more in regard to the position and number of the heads employed. Next there is the linear contraction which takes place after solidification sets in; this comes in all directions, and varies according to the density of the metal used. It is about this contraction I more particularly wish to speak.

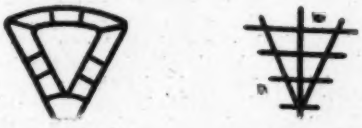
A word here regarding the position of the pattern-maker and the moulder toward this problem would not be out of place. Let us assume first that the steelmaker is supplying a high-class metal that in every way meets the analysis required and the tests expected, and that the engineer or designer has produced not merely a possibility, but that he possesses a fair knowledge of what moulding and casting means and has designed accordingly. On receiving the drawings of a big and intricate job, the foreman pattern-maker, if he is a wise man, will study the job until he can visualise it in its right perspective. He will then determine which is the correct way to mould and cast the job. If he is a superwise man he will then send for the foreman moulder and obtain from him a decision as to which way he intends to mould and cast it, then with a knowledge of the metal to be used he

BASE PLATE. ENTABLATURE.

FIG. 3.

will make the necessary allowance of contraction of the metal. This contraction is bound to occur; and the amount of it can be determined with almost mathematical precision, and that is the pattern-maker's business.

Now if moulding were as simple a job as the average moulder's ignorance of the forces that are set in motion when his work is being cast would suggest it is, then there would be some reason in the gibe so often uttered by irresponsible outsiders, that moulding was only a semi-skilled labourer's job. But successful moulding and casting in a large foundry is not obtained by the hit-and-miss methods so often prevailing, and the time has come when if we are to successfully compete with the outside world in the founding industry, the moulder must be as technically proficient in his job as the pattern-maker and the engineer are compelled to be in theirs. He must realise that contraction and expansion are not the pattern-maker's business entirely; he is concerned with the contraction of the metal, and the moulder should be concerned with the contraction of the casting. Whilst it is



No. 1 METHOD. No. 2 METHOD.

FIG. 4.

impossible to stop the contraction which must come on the metal, one can most successfully stop the contraction that ought to come on the casting, and there lies the danger of a hot tear, a pull or a crack, the result of the unexpected strain placed upon the job. This may be illustrated in a very simple manner by the sketches in Fig. 1, of three different castings—No. 1 a rectangular plate; No. 2 a square box; and No. 3 a cylindrical casting. The chief difference between these castings is one of configuration only, but they have several

* Read before the Sheffield Branch of the British Foundrymen's Association, February 15th, Mr. J. Little in the chair.

things in common, viz., thickness of metal, superficial area and cubical contents; consequently the moulds for the three will have the same capacity, and the castings will be the same weight. The contraction of the metal and that which should occur in the castings will be identical. The contraction of the castings, however, will depend on how the job is constructed, for it is easy to impede or suspend the contraction of the castings. This can be easily demonstrated by measuring up the casting; the rectangular plate will in all probability give the required dimensions, while those of the other two will depend entirely on how the cores are made.

Fig. 2 shows the sectional elevation of a conning-tower roof plate, 15 ft. long, 10 ft. wide, 2 ft. 6 in. deep. The castings are made from armour-quality steel, and the pattern-maker makes the necessary allowance for contraction. As, say, 20 of the castings are required, the moulder who is seeking output perhaps decides to have a chill made for his top part, to obviate the necessity of ramming up 20 tines. The pattern is placed in position, the bottom rammed up, and the joint made, the chill is placed in position, and the top part put on and fastened to it; then follows in natural sequence, lifting of top, drawing of pattern, finishing the mould, drying, closing and ultimately the casting. Then the moulder will probably find the job in half-a-dozen pieces; or if it isn't, that is the finest tribute that can be paid to the steelmaker, for a stress has been placed on that casting that was never calculated for. The use of a chill in the way indicated is, I know, an absurd proposition, and no man in his right senses would ever dream of doing such a thing; nevertheless, one may ask, Why not? Why should we expect a casting made in such a manner to be in half-a-dozen pieces? The chief reason is that by this method of constructing the top part the contraction of the casting is successfully arrested. and because one cannot at the same time arrest the contraction of the metal, fracture is inevitable. Why, then, do we find in the making of such a mould a top part which rivals a cast-iron chill in its rigidity and inflexibility. In the length of such a casting there should be about 3 in. contraction, in the width 2 in., and in the depth ¼ in. This contraction the patternmaker must allow for, but it is the moulder's part to construct a mould sufficiently strong to withstand hydrostatic pressure, and yet sufficiently weak to allow contraction to proceed unrestricted. In casting such a job there are two forces set in operation, which, for a time at any rate, are in opposition to each other. Directly the hot steel is poured into the mould, by the process of conduction the cast-iron grids in the top part become heated and expansion takes place, until the time when equal temperature is reached. Before that time, however, sodidification takes place in the casting, and a linear contraction in every direction follows in due course, and is in direct opposition to the expansion in the cores. Hence the necessity of so constructing the top part that its chief virtue is not rigidity but flexibility.

Fig. 3 shows sectional elevations of a base-plate and an entablature. The chief difference between these two castings is one of metal section only, one being 2 in. the other 4 in. thick. We will assume that the length, breadth and depth are equal, *i.e.*, 10 ft., 5 ft., and 5 ft. respectively. Here is a different type of casting which will require different methods of moulding, feeding and casting. It has metal on all sides of the cores with strengthening walls in between, the cores in each partition cutting through the top part. For ventilating purposes this would be cast with the outlets in the top, and in closing the cores would be fastened to the top part, the bottom resting on studs. The contraction of these castings, so far as volume of metal is concerned will be in correct ratio one with the other, but the contraction of the castings themselves will depend entirely on how the mould and cores are constructed and the arrangement of the heads. If this latter contraction does not appear it implies that a stress is present, and that will often account for a broken casting, even though a test taken from the same cast will give the best tensile requirements of that class of steel. The principle that should guide the making of such a job, particularly the cores, is to make them as weak as possible consistent with a sound job.

There is another force which comes into operation during the casting of such a job as this—the force of gravity. It is operative in most castings, yet it very often happens that the construction of mould, arrangement of heads and method of casting are all carried out with an entire disregard to this very important factor. In such a casting there is an inch of contraction that must occur in a vertical direction; and if the top part is in any way tied up the cores and core irons must be crushed up an inch, so that when the casting is cool there will be a space of 1 in. between the bottom of the casting and the bottom of the mould, *i.e.*, after contraction the whole weight of the casting is suspended in opposition to gravity. This necessitates so constructing the mould, arranging the heads and placing the brackets that when contraction occurs it may do so with as little resistance as possible. A fruitful source of failure in some castings is the shape and strength of the cast-iron grids or lifting irons in the cores and mould. They should be made only sufficiently strong to carry the job, and greater dependence should be placed upon the binding quality of the moulding sand. Fig. 4 illustrates this point, and shows a grid made to carry a core for the inside of a spur or flywheel. No. 1 is the strongest possible design for the job, and one which will give the greatest amount of resistance to contraction, yet it is a common design simply because the contour of the box suggests it. A more suitable iron is shown, No. 2, which has all the strength required, and offers less resistance to contraction. The pressure on the outside of the core caused by contraction on the one hand, and the expansion of the core irons on the other, will by this method reduce to a minimum, inasmuch as the sharp points of the core iron will cut through the compo. as the pressure increases.

Discussion.

Mr. F. Darley considered that contraction was responsible for 75 per cent. of failures, both of steel castings and ingots. There were many things that governed it—the heat of the metal, differences in the analyses, differences in the content of carbon and manganese. One could cast two moulds out of the same ladle, both of the same size, and one might come out appreciably smaller than the other. In instances that had come under his observation he found that the one cast first was the smaller, from which he concluded that the

hotter the metal the greater the contraction. There were other things to be considered, as, for instance, the distortion of castings due to contraction. The same thing was responsible for "piping," which took place on account of excessive contraction, the material setting on the outside before the centre.

Mr. T. Brown said his conclusions differed entirely from those of Mr. Lynes. The moulder knew best how to make a mould, and therefore how the pattern should be made, and the patternmaker should therefore work entirely to the directions of the foreman moulder. Whatever contraction occurred did not occur equally, and there was bound to be some deformation, no matter how the mould was prepared.

Mr. John Watson considered that in the steel foundry the weak spot was the moulder, who knew very little indeed about contraction and expansion. Many times a moulder made a job and suspended it on the assumption that the contraction always came from the riser, simply because the riser was the bigger portion of metal; and many castings were, in consequence of that assumption, put on the scrap heap. In the matter of visualising castings he thought that in this country there had been very much amiss in the training of foremen moulders, patternmakers, and moulders. Nine-tenths of the men in the works could not visualise a casting when a drawing was put in front of them. When a drawing was put in front of a moulder, he should be able to see the finished casting just as if it were a photograph. As a foundry manager he urged moulders to get rid of iron cores.

Mr. Brown, referring to the remarks about core irons, said that in the case of a gear wheel, for instance, he would not hesitate to use a plate.

Mr. H. Bradley thought one point had been missed on the core-iron question. It should be realised that when a core iron was made similar to that shown in No. 2 of Fig. 4 the core iron would to a certain extent expand the core, and when cool the core iron would contract to its original size. When making a large core they would never make it to the ordinary contraction rule, but make it less the difference between iron and steel, and the core-box would be made so much smaller to allow for the expansion of the core iron.

Mr. Lynes said Mr. Darley's experience with the differing sizes of castings from the same mould might be accounted for by the fact of the mould being very hot. He quite agreed with Mr. Brown that the moulder should be the man who should say how a job should be moulded, but he did not always do so, for the simple reason that he could not say which way to mould until he got the pattern. With regard to test pieces, he contended that the true test of a piece of steel was the test from a piece without any stress. If a test were taken from a casting cut up it would have had stress already put on it. The mould should be so constructed as to relieve that stress to the very greatest extent possible. With regard to Mr. Bradley's remarks, it was always his (Mr. Lynes') practice to make the core-box to a different contraction to that he allowed for the pattern. That was essential because of the swelling that took place in the moulding sand and of the swelling that took place in the core iron, which never got back to its original condition. Every patternmaker who was wise would make that provision in his core-box; otherwise he would never get the thickness required

The Branch-President said he was struck by the great difference in the training of the moulder's apprentice as compared with the patternmaker's apprentice. A good deal of the failure of the former was due to the fact that the boys did not apply themselves to the study of even the rudiments of drawing, while it was quite an understood thing that the patternmaker must learn drawing. The younger men now studying the trade were perhaps doing a bit better, but he would guarantee to take a dozen moulders of, say, fifty years of age of whom not one would be able to understand even an elementary drawing, and if given one of even a fairly common job could not go and pick out the article it represented in the fettling shop. That being the case, they could not expect the patternmaker to ask advice from the moulder.

Mr. A. Weniger, speaking as a steelmaker, was not prepared to say that nothing depended on the temperature of the steel; he believed a lot did depend on that, and also on its chemical composition. If the steel was given to the moulder very hot, it first cooled on the outside in contact with the mould, while the interior would remain exceptionally hot due to the initial temperature, and it seemed to him that in a case like that there would be some contraction to take place after the steel reached a rigid, pasty condition. Consequently more consideration should be given to what constituted a reasonable casting temperature, and also to the time taken in pouring the steel, so that it did not enter the mould too rapidly. Then with regard to the composition of the steel, the higher the carbon content the lower the solidifying point of the steel, with less contraction to take place; and he would therefore advise making the steel with as high a carbon content as possible, provided the requisite test was obtained.

The President suggested the formation of a junior section of the Association. The moulding trade was much the most skilled engineering trade, and the only reason the moulder was not more often consulted was the fact of his ignorance of his own business, and particularly in the matter of drawings. Certainly he would welcome anything that was done to encourage apprentices to attend meetings of the Association, but it was for the men in the shops to put it to the youngsters. The time was approaching when apprentices of all classes would have a very different career and different opportunities to those of the past. Hitherto it was merely necessary for a lad to spend a few years in a shop, the first year spent perhaps in sweeping up and the others in more or less idling about. It was nobody's business to teach him the trade, and he had to pick up its rudiments in the best way he could. He maintained it should be the business of one man to teach the trade to the apprentices, and he should be paid to do it, in addition to his ordinary pay. Hitherto the sole ambition of a youngster on entering a shop was to spend the few years necessary to joining the trade union, and then he considered he knew all there was to know about the trade. He was, as a result, turned out at twenty-one little better than a semi-skilled labourer, and perhaps 1 per cent. of the men so trained were equal to the responsibility of tackling a serious job. He was certain that when the war was over there would have to be some definite provision by which apprentices would be thoroughly taught their work.

Lead-Tin-Antimony Alloys.*

By O. W. Ellis, M.Sc.

The investigation now described had for its aim the determination of the applicability of certain of the cheaper ternary alloys of lead, tin, and antimony in the manufacture of small fittings subsequently to be submitted to tensile stresses varying in amount up to 10 tons per sq. in. While the results of the trials have proved of little value in the connection for which they were instituted, they may yet serve a useful purpose, particularly as certain of these alloys are now being utilised in the manufacture of die-castings. They are, for this reason, published.

The strengths in compression of a few of the alloys of lead, tin, and antimony have been determined by Charpy, whose tests were made on prisms of the alloys in question, each prism being 15 mm. in height and of 10 mm. square section. Only one of the alloys examined by Charpy falls within that portion of the system examined by the author. The full list of Charpy's tests is, however, given below :—

Lead.	Tin.	Antimony.	Load corresponding to a compression of 0.02 Mm.	Load corresponding to a compression of 7.5 Mm.
Per cent	Per cent.	Per cent.	Kilos.	Kilos.
80	10	10	800	1,775
60	20	20	1,050	1,700
40	40	20	1,150	1,825
20	60	20	1,350	2,200
10	80	10	1,100	2,700

The constitution of this system has been considered by Loebe, and by Campbell and Elder. The constitution diagram has been shown by these observers to be divisible into four areas, portions only of three of which have been dealt with by the author. That section of the constitution diagram

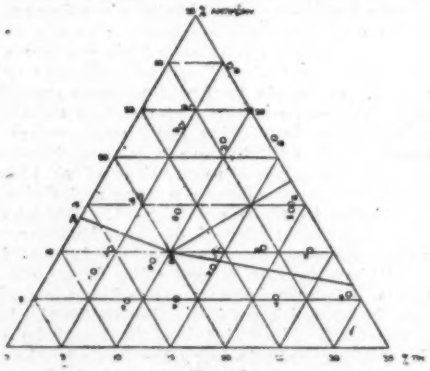


FIG. 1.

with which this note is concerned is shown in Fig. 1. The alloys that have been examined by the author are, for convenience, indicated in the diagram by circles, against which are affixed the numbers by which these alloys are designated below. All the members of the series, with the exception of No. 20, were chemically analysed subsequent to test, in order that due allowance should be made for possible errors in mixing or in manufacture.

* Note presented before the Institute of Metals, March, 1918.

The alloys were made from high-grade metals of commercial quality. The lead and tin contained only traces of impurities; the antimony was not analysed, but a full analysis of one of the test-pieces failed to reveal more than traces of elements other than the three components of these alloys. The alloys were made up to 400 grms. in weight, and subsequent to melting were cast at as low a temperature as possible consistent with efficient pouring; not more than traces of dross were observable on the " melts " prior to pouring. The alloys were cast in chill moulds ½-in. in diameter. The cast rods obtained approximated closely in general dimensions to the small fittings already referred to.

No.	Lead (by difference).	Tin.	Antimony.
1	88.0	4.1	7.9
2	86.5	8.6	4.9
3	81.8	13.1	5.1
4	76.8	14.8	8.4
5	72.6	22.1	5.3
6	65.7	28.7	5.6
7	85.2	4.6	10.2
8	82.0	8.9	9.1
9	75.1	14.7	10.2
10	71.0	18.6	10.4
11	66.8	23.0	10.2
12	79.6	4.5	15.9
13	77.1	8.6	14.3
14	66.4	19.0	14.6
15	66.0	18.9	15.1
16	70.1	4.6	25.3
17	68.8	9.1	22.1
18	64.1	13.9	22.0
19	72.2	4.5	23.3
20	65.0	10.0	25.0
21	64.2	5.9	29.9

From the cast rods sections for the manufacture of tensile test-pieces were cut. Three of these test-pieces were fractured in turning—Nos. 13, 16 and 20—though the machining of the test-pieces as a whole was conducted with apparently equal care and skill in all cases. The residues of the rods were retained for manufacture into compression and hardness test-pieces. Unfortunately, certain of the compression test-pieces were mislaid, and time has not permitted of the production of other test-pieces of the same composition.

The tensile test-pieces were 0.326 in. in diameter and 1.155 in. between the gauge marks, the latter distance being four times the square root of the cross-sectional area of the test-piece. The compression tests were made on test-pieces having a sectional area of 0.25 sq. in. and having a length equal to twice the diameter of the samples.

The following table includes the results of all the tests made on the alloys in question. The results are considered sufficient to merit the following conclusions :—(1) That the effect of the presence of the tin-antimony compound in these alloys is such as to render the same brittle and weak; (2) that the general mechanical properties of the lead-tin-antimony alloys containing less than about 15 per cent. of tin are improved by the addition of antimony in quantities not exceeding about 10 per cent. The lines A B and tin 15 per cent. in Fig. 1 appear to enclose the alloys possessed of the most satisfactory mechanical properties in a general sense; and (3) that, as far as that part of the diagram shown in Fig. 1 is concerned, the effect of increasing the content of

antimony in any alloy is to lead to an increase in the hardness of the same. There appears, however, to be a region of maximum hardness in the vicinity of the 70 :10 :20 alloy :—

No.	Yield Point. tons per sq. in.	Tenacity. Tons per sq. in.	Elongation. Per cent.	Compression load in tons required to compress to half length.	Brinell Hardness number. 10 Mm. ball, 200 kilos.
1	2.14	2.41	1.5	12.7	15.2
2	2.14	3.22	3.0	N.O.	15.1
3	2.68	3.35	2.0	N.O.	16.7
4	2.81	3.08	1.0	N.O.	18.0
5	N.O.	2.41	—	8.9	16.8
6	2.95	3.75	1.5	N.O.	15.1
7	4.01	6.17	10.5	12.6	23.2
8	3.86	6.43	13.0	11.0	25.4
9	3.75	6.43	5.5	N.O.	26.4
10	4.01	5.09	1.5	9.0 C	23.2
11	3.75	5.36	1.0	N.O.	24.0
12	3.08	5.22	4.0	N.O.	25.6
13	Broken in machining			11.6	31.0
14	3.48	5.36	—	10.7 S.C.	32.0
15	3.48	5.36	1.5	9.7 S.C.	27.6
16	Broken in machining			12.5 S.C.	26.6
17	4.55	4.55	—	9.8 *	37.0
18	4.28	5.09	—	10.0 *	35.6
19	3.48	3.48	—	8.8 *	27.8
20	Broken in machining			8.3 *	33.6
21	3.75	5.62	1.0	6.5 *	28.8

N.O.—Not observed. C.—Cracks in compression test-piece. S.C.—Slight cracks in compression test-piece. * Failed without compression to half length.

Steel-Making and the Use of Electric Furnaces.

At a meeting of the Keighley Association of Engineers, Mr. T. H. C. Homersham (of Thwaites Bros., Limited) read a Paper with the above title, in the course of which he pointed out that irons containing from 2 per cent. to 2½ per cent. of silicon are blown in what are known as side-blown converters, that is, instead of the air being forced through the bath, it is blown at a pressure of a few pounds per square inch on the surface of the metal, and so great is the heat caused by the combination of the silicon with the air, that the whole contents of the vessel circulate, and the silicon and carbon are very nearly wholly removed. Here comes in the skill of the operator, as, if all the carbon is removed and the bath becomes one of practically pure iron, so great is the affinity of pure iron at high temperatures for oxygen, that it occludes oxygen from the air and forms a frothy, spongy mass which is quite uncontrollable; an unfortunate condition which the steel-maker calls "over-blown." Side-blown converters can only be conveniently worked with an acid lining, so are dependent upon the use of an iron high in silicon and low in phosphorus.

Turning to electric furnaces, in the open-hearth process the gas producer was known to have a thermal efficiency of about 65 to 70 per cent. measured on the calorific value of the coal burnt, and the furnace itself had a thermal efficiency of from 12 to 15 per cent., the great bulk of the losses being due to the escape of the hot gases or what are ordinarily called in boiler practice, "chimney losses." In the converter plant the thermal efficiency of the fuel used in the cupola was known to be only about 40 per cent., and the combined losses of iron owing to oxidation in the cupola and converter were known to be from 15 to 20 per cent. On the other hand, the electric furnaces dependent upon energy from a coal-consuming station were proved to have a thermal efficiency of from 70 to 75 per cent., but the generating plant itself was known to have a thermal efficiency of only from 12 to 15 per cent. It will thus be seen that so far as thermal efficiency is concerned, there does not appear to be any very overbearing competition with the older methods due to the entry of electric furnaces upon the scene, when the resulting loss by oxidation in the Bessemer process is added to the balance sheet. There are, however, other considerations to be taken into account which in many installations are of the first importance.

First perhaps is the fact that the electric furnace can deal with those forms of steel scrap which are the most abundant because they are the most difficult to use up in furnaces of other types, viz., light steel scrap such as steel turnings, punchings, foundry scrap, etc. Next is the fact that there is practically no loss of iron due to oxidation, as for all practical purposes no iron need be lost from a closed furnace of this type. After these is perhaps the advantage that the fuel is brought to the furnaces by means of a cable instead of by coal trucks.

Beyond mentioning the names of some of those men who interested themselves in the earlier stages of the application of electricity to metallurgical purposes, the author had not endeavoured to go into the respective merits of the various "patent" electric furnaces which have been so hotly contended for at meetings dealing with this subject. He had yet to find that the results obtained by any one type of furnace were very different to those obtained in any other, given equal conditions and supervision. It might, however, be well to mention the various types of furnaces in which an electric arc was used, and he thought they could be divided broadly into three categories:—(1) Those furnaces in which the whole of the electrodes pass through the roof or walls of the furnace. (2) Those furnaces in which the whole of the hearth is turned into an electrode. (3) Those furnaces which have one or more water-cooled steel electrodes embedded in the hearth.

To illustrate the third type the author took the Snyder furnace, as at the works with which he is connected they have several of these, and he is naturally most conversant with the results from them. In this type, one carbon electrode passes through the centre of the roof, and the other is a steel water-cooled electrode embedded in the bottom of the furnace, which may be of either basic or acid material, as in this case the current has not to find its way through the refractory material to the electrode. These furnaces are connected to one phase only, and consequently their power factor, when working on a three-phase supply, is very low compared with the other types; but this condition can be reasonably improved by a variety of means (at the works in question they have a large asynchronous motor-generator set for that purpose), and a special rotary machine has been designed by Professor Miles Walker, which is in satisfactory operation and gives practically a unity power factor with one furnace of this type working on a three-phase supply. This machine is called a phase balancer, and is in effect a three-phase to one-phase rotary converter, with such heavy inductive resistance that, on a short-circuit, the current is choked back and the machine runs light.

Jar-Ramming Moulding Machines.

At a recent meeting of the Birmingham Branch of the British Foundrymen's Association a discussion on "Jolt-Ramming Moulding Machines" was held, Mr. J. Shaw (Branch-President) in the chair.

The discussion was opened by Mr. H. Pemberton (Derby), after which Mr. Anderton Wardle (Coventry) gave a paper, with illustrations, as follows:—

Jarring machines are by far the most useful and most generally applicable of all types of moulding and core-making machines at present in use. This remark is based on actual experience with several of the very best types of hand and power press machines. The ordinary hand-ramming type of machine simply helps the operator to draw the pattern. The hand-power press machine is better, but all the work performed has to come from the operator. The machine helps him only by equalising mechanically the work units performed. The power press is still better, inasmuch as the work is performed by the power plant, be it pneumatic or any other power. This type of machine, the power press, is very efficient and satisfactory on shallow work, and materially increases the output and reduces costs when employed on suitable work. The jar machine even on most kinds of shallow work will equal the power press, and on all other types of work is infinitely superior, both from the standpoint of economy and better moulds. As is well known, the jar machine rams the sand hardest close to the pattern, and it becomes gradually more open towards the outside of the mould, thereby facilitating venting. Its use will allow considerable reduction of the amount of sand used, it being possible to reduce the size of the moulding boxes. This is due to the fact that a mould can be rammed with the minimum thickness of sand between the pattern and moulding box. In one case (that of a steel wheel for a large lorry) the wheel was about 3 ft. 6 in. diameter, 10 in. deep, the thickness of sand in the middle moulding box being not more than 1 in. thick. A press could not make a satisfactory mould under these conditions.

Intricate work, such as air-cooled cylinders, are being made very successfully on jar-ram machines, without any hand-ramming whatever. The moulds are far better than the most careful moulder could make, being more uniformly rammed, and in a fraction of the time.

No type of press machine, so far as I know, is suitable for ramming under a loose piece projecting from the body of the pattern. A jar-ram machine will accomplish this in the following manner. The loose piece should be removed and sand filled into just above its level, then jarred. After which the loose piece should be inserted, the remainder of the sand filled in, and the mould jarred a second time. In some cases it is necessary to tuck sand under the projection with the hand and also on very accurate work to reduce its depth to allow for the sand falling away a little during the second jarring.

Another very important advantage on straightforward work is that the machine will ram the mould during the time the sand is being filled in, and by the time the mould is filled it is also rammed.

All moulding machines should be fitted with pattern-drawing appliances. A plain jar machine with a good pattern-drawing appliance, is nearly always better than a turnover machine, inasmuch as the operations of turning over and back again are dispensed with. Of course, in some cases, a turnover machine is absolutely necessary, but is often used when the same results could be obtained at less cost on an ordinary machine.

FIG. 1.

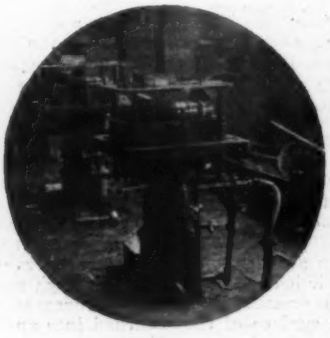


FIG. 2.

FIG. 3.

In one large foundry in which I have spent many unhappy hours there are 70 jar-ram machines in regular work; 67 of these are ordinary standard type and three are turnover machines. This foundry is doing, perhaps, some of the most intricate and exact work in this country.

With reference to speed of mould-production, in another foundry, two girls, working one small machine, are turning out daily as many as 400 boxes, each containing eight plugs about 5 in. long and 2¼ in. diameter at the large end. These plugs are used for making the ends of projectiles dustproof. Jarring machines have also great possibilities in core making.

Thousands of air-cooled cylinders for motor-cycle and aero engines, with fins cast on nearly all the way down the barrel, in some cases 1¾ in. deep, have been made on the jar-ram machines, without any hand-ramming whatever. Fig. 1

shows a machine engaged on this work ready to receive the moulding box. Fig. 2 shows the stripping plate raised. The moulding box should, of

Fig. 4.

course, be in position on the top of the stripping plate, already jarred, when this operation is performed.

Fig. 3 shows the stripping plate being lowered from the mould. The moulding box is left standing on auxiliary stools; the main stools will be seen lowering the stripping plate away from the mould. The actual time taken to make a mould and draw the pattern for an ordinary aero-engine cylinder is 7 minutes.

Fig. 4 shows the back axle and brake cover steel castings for a large motor lorry. In Fig. 5 is seen half the back axle casing pattern on the machine ready to receive the moulding box. This pattern is located on to the machine by dowels, and after a number of the cope halves have been made, this half is removed, and the drag part put on in its place. Of course, where large output is required, two machines, one working on each half pattern, would be preferable. Fig. 6 shows the machine lifting the moulding box from the pattern.

Fig. 7 shows a turnover machine, which takes moulding boxes up to 30 in. square. The pattern draw is 8 in. The pattern shown on this machine is the inside or bottom part of the brake cover shown in Fig. 5. This is a job where a turnover machine is advisable, as the deep part would not lift out satisfactory on an ordinary machine unless special boxes were made with bars passing right down to the inside of the pattern, and even then bars would possibly retard contraction and cause a crack.

Fig. 8 is a smaller and very useful machine. It will be noted that the table is a frame, which makes it possible to use a double-sided cast pattern plate.

Fig. 9 is a small jar-ram core-making machine, showing also a core which a girl has made. The machine jars up the core, which is then turned over on its drying plate by hand. The operation requires two girls. The core box is afterwards lifted from the core by the machine. This core is about 18 in. long and 15 in. deep.

The apparatus in Figs. 10 and 11 is a jar-ram core-making machine, and the writer considers it is by far the most efficient machine in use for the purpose for which it is intended, that of making round, square, or any other shape of straight core up to, say, 24 in. long. Four cores are made at one time. A youth can make four cores up to 9 in. diameter in 1¼ minutes. The machine is enclosed in a cast-iron circular dust- and sand-proof casing, with all joints machined, and bedded into the floor. The cores are perfectly parallel. The core boxes are shown on the top of the machine, with a small hopper to guide the sand into each of the four core boxes as the machine is jarring. The large hopper contains the sand supply. The machine pushes the cores out of the core box in stages, one core is pushed up about ½ in., the other three follow in steps of ½ in. This takes less power than

Fig. 5.

Fig. 6.

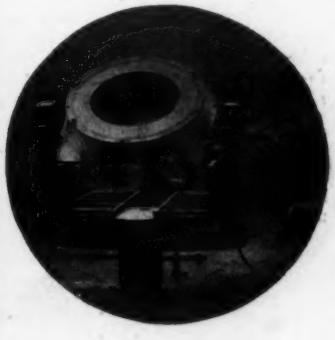


Fig. 7.

Fig. 8.

pushing out all four cores at once. The first core after being pushed up ¼ in. is thereby released before the second core is moved, and the power

Fig. 9.

taken at any one time is only equivalent to pushing out one core, not four. The four cores can, if necessary, be made all of different lengths.

Discussion.

Mr. A. R. Bartlett (Belvedere, Kent) said that he had had some years' experience of jar-ramming machines on different jobs, and the experience of the work in which he was interested it was necessary to be more accurate than in other classes of work. In his work, for overhanging parts he made prints and cores, and work was then capable of being jar-rammed. Both the shockless type of machines and the rigid type were in use on the work with which the speaker had to deal, the large work being done on shockless machines. He had smaller machines for another type of work, but these were used principally for work in the coremaking shop, in which there were no overhanging parts which were not suitable for jar-ramming. Certain turbine cases with which he had to deal were rather big ones, and all the external parts and most of the internal parts were jar-rammed. The cores were rammed up on somewhat similar lines to those mentioned by Mr. Wardle, but they were carried in on a rather longer curve, and of course the outside or core print was quite plain. The core was rammed with the flat surface up, the projecting parts being in the base of the corebox, and then it had to be turned over, but they cast grids and dabbers which fitted into the box. Two inches of sand was put into the box and slightly jarred to harden the sand, then the core iron was placed in position, necessary vents placed in, and then the box was filled up. Of course, it was not filled up solid, because there was a passage needed in it for the vents. He could hardly understand how a core could be rammed up in the time mentioned by Mr. Wardle. Of course, the ramming itself would only occupy a few minutes, but time must be allowed for other work necessary to prepare and complete the job. All these things took time and required a skilled workman, and it was necessary to take all this into consideration when stating costs. At the same time, a highly skilled man would rather have the ramming done by the machine; for one thing, it did not hurt

Fig. 10.

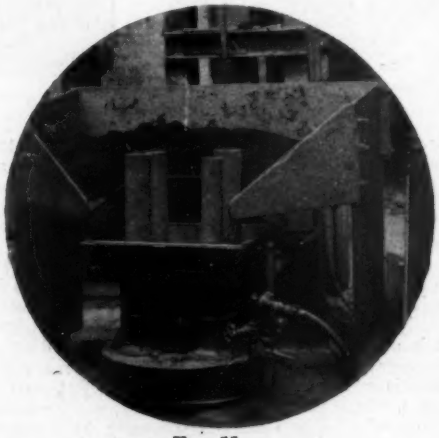


Fig. 11.

Mr. Pemberton and Mr. Wardle corroborated his own. It was quite common knowledge that jar-ramming machines would ram only on straight lines. As to Mr. Wardle's remarks respecting bosses and other protruding parts, and his ability to allow a shortage on the pattern to make up the tendency of the sand to drop on the second ramming, he had invariably found that he could not judge properly the allowance. It might be that in his knuckles as did the former method of ramming, and his energy was saved for further effort and a larger output thereby secured. To prove how simple these machines were, he might mention that a girl had been working for a fortnight on the 3-in. cylinder machine, and he now could not get her off the machine; if he sent her to make an ordinary core she did not like the job. It showed how simple the work was with a jar ram-

ming machine when a girl of 15 years of age could be got to work it so successfully.

Continuing, Mr. Bartlett said he would like to mention to Mr. Shaw the possibilities of making cores. He (Mr. Bartlett) had a little pneumatic sieve with an 18-in. riddle. As he wanted a very small jarring machine he took the cylinder off the end of the screens and arranged it so that it would act as a jarring machine for cores. He fitted a table on to the end of the piston and placed the machine in such a position that the piston in coming down would not allow the table to drop to the original extent, but would hit a ring on the bench, and thus be stopped. This formed a very satisfactory jarring machine, and they could turn the cores off very much faster with it than by hand-ramming. The girls found out the advantage of the jarring machine, because they found that they could give the corebox a good ram by simply using the machine instead of having to deal with it by hand. One reason why jar-ramming was far better than hand-ramming was that one did not get hard spots either in the mould or in the core. He had also adapted two other pneumatic sieves which he had in the shop to form jolt-ramming machines. On these comparatively very small cores were rammed, the machines saving most of the ramming time and giving a better core. It was possible to ram a core eight inches or nine inches long with a 1¼ in. hole at the top and bottom and a bellied centre quite successfully. Any plain core paid for putting on these small machines.

In reply to a further question by Mr. Reason, Mr. Bartlett said jar-ramming had the same effect as when the box was dropped on to the bench: the sand solidified, and when the box was turned over the sand was tighter on the bottom side than on the top. This was not the case with cores rammed by hand in the usual way, as they were ofttimes hard in some places and soft in others and did not vent so easily. These cores were not so large as the others previously spoken of. These cores had to be vented, because they were cast on the flat. When a core was jar-rammed it did not appear to the average man as hard as he would like it to be. Mr. Wardle had spoken of jolt-ramming making the sand hard and dry, but his experience was that the sand mixture did not need to be as wet as was generally used for hand-rammed work. As to standard boxes, in his foundry there were a variety of standard plates and boxes for the large jarring machines. They had centre lines on the plates and on those lines holes were drilled to receive the pattern pins and at certain spaces at right angles to those lines there were other holes evenly spaced to receive irregular-shaped patterns. They had drawings of these pattern plates and patterns numbered: and in the making of every pattern that was likely to go on the jarring machine the foundry was consulted, and they advised a certain size of box and the pattern plate to be used. The boxes were numbered, and they had only got to turn to the drawing to show the patternmaker where to put the dowell plates or to make the pattern to receive the dowell plates. Thus they simply had to drop the pattern into its place and the dowell plates would fall over the pins along the centre lines and the cross lines of the pattern plate. Another feature was that one only required to have a certain number of pattern plates.

Mr. Ben Hird (Peterborough) said that the "bumper" or jar-ramming machine could be used for many classes of work. He had had a large variety of jobs rammed up on it, and agreed with Mr. Pemberton that the machine could deal with almost any job of the split-pattern or flat-back type. For jobs that were not standard he had used stout turnover boards instead of plates. These were made of 1¼ in. boards cross-lapped, with 3 in. by 4 in. battens about 6 in. apart. Iron plates about 5 in. square were screwed on to take the pins. These were not so good as iron pattern plate, but had the advantage of being much cheaper. The disadvantage of the boards was that sometimes after the top moulds had been finished and turned over, pieces of sand about an inch thick would drop off the joints. He thought this was caused by the spring of the boards forming a double joint in the mould. With reference to pattern-drawing machines, he thought that with good patterns and true pins of a suitable length these could be dispensed with for many jobs. He was making radiator tops for motor lorries and the two labourers working the "bumper" were lifting the moulds off the pattern plate very satisfactorily with the aid of the crane.

Mr. F. J. Cook said that it had not been mentioned by any speakers except as a disadvantage how the jar-ramming machine dealt with undercut work. It was objected that with a machine one could not ram properly certain undercut sections. He believed it was generally considered that a jolt would ram at an angle of 45 deg. Why, then, could not the box be altered so as to enable this to be done? Mr. Cook illustrated on the blackboard how he considered the difficulty could be got over, and said that by this means a saving of work could be effected.

SAND-BLASTING.—Mr. H. L. Wadsworth, in a Paper read before the American Foundrymen's Association, contended that for all but the lightest castings, provided conditions are proper for the operator, hand operation is superior to and more efficient than automatic operation. With hand operation spots of scale which are found hard may be given extensive cleaning, while softer spots may be more rapidly passed over. With this in mind, he said, sand-blast machinery manufacturers are aiming in their designs for strong, well-paced exhausts in connection with proper lighting of the work. For medium-sized castings weighing from 50 to 500lbs., which do not require handling by a crane and which are too large to be handled in tumblers or automatic machines, he considers the rotary type of sand-blast room, consisting of a heavy revolving table frame divided into two parts by a heavy cast-iron partition, popular, especially in automobile and light machinery foundries. With such equipment the operator works in a small steel room and when he has finished the castings on which he is working he revolves the table a half-turn, which takes the finished work out of the room and puts the new work before him ready to blast. This equipment has the following advantages:—Less floor space for a given tonnage; reduced and strongly lighted working area so that there are no shadows, and practically continuous operation with correspondingly high efficiency and low costs. Endeavours to improve further on the rotary-table type of sand-blast room led to the design of a room in which the operator stands outside, viewing the work through a fine-mesh brass-wire screen, the sand-blast nozzle being operated through a slot of soft rubber in the steel casing of the room. However, in the opinion of the author, the necessity of the operator being inside the blast room is no disadvantage. In regard to the sand, for practically all work, a hard-grained flint sand manufactured from quarry rock of comparatively fine mesh gives, he said, the fastest cutting.

Iron, Carbon and Phosphorus.*

By Dr. J. E. Stead, F.R.S.

This Paper may be taken as continuation of one read before the Institute in 1915.

Section I.

It has been proved that when alloys of iron, carbon, and phosphorus are heated to the point of incipient fusion, the phosphorus and carbon become concentrated in the part that first becomes liquid. On the other hand, it is well known that if the same alloys after complete fusion are gradually allowed to solidify, the last portion to become solid contains much more carbon and phosphorus than the parts which first solidified. It has been shown by Professor Arnold and others that alloys containing traces up to 1.36 per cent. phosphorus and practically no carbon, when allowed slowly to solidify and cool, contain all the phosphorus in solid solution, and that if the carbon is gradually increased in the liquid metal, after solidification it contains more and more free phosphide of iron, and that when a maximum amount of carbon is present the greater part of the phosphide exists in the free state in a eutectic mixture.

It has further been proved that when a steel of medium carbon content becomes completely solid and is then slowly cooled the portions richest in phosphorus are quite free from carbon, although it is known that the two elements must have been in association at the point of solidification of the steel.

The fact that prominent metallurgists refer to phosphorus as treacherous is clear proof that the reason for its variable effect is not known. But for the knowledge gained by years of research on the influence of carbon on iron, that element probably would be considered even more treacherous than phosphorus. We have gained knowledge, and now know how to control the effect of carbon.

The author's conclusions from his own experiments as described in this Paper, and from experiments made by others, are summarised as under:—

(1) It has been proved that the pearlite areas in medium carbon phosphoretic steel castings, and the ferrite immediately enveloping these areas, contain much less phosphorus than the ferrite exterior to them.

(2) Conclusive proof has been advanced that as carbon enters into phosphorised iron by cementation, the phosphide of iron diffuses out of the areas invaded by the carbon, and is concentrated in solid solution in the surrounding ferrite, and that this concentration increases as the carbon increases, probably at temperatures just short of incipient fusion, until the ferrite becomes saturated with the phosphide, and, when that point is reached, although carbon may continue to increase in the carburised portion none will enter the saturated solution of phosphide.

(3) The amount of carbon capable of passing into iron by cementation at any given temperature, short of the ternary eutectic formation point, depends upon the amount of phosphorus present in the iron and varies inversely with the phosphorus.

(4) If the temperature of the cementation furnace exceeds the formation point of the liquid ternary eutectic, the internal tension in the ferrite rich in phosphorus, due to the continued increasing external tension of the invading carbon, at last becomes so great that the phosphide is forced out of solid solution in the very centre of the ferrite, forming a eutectic liquid.

(5) It is confirmed that graphite can carburise iron without the interposition of any gaseous vehicle, and that the carbon, in diffusing from graphite nuclei bedded in iron containing phosphide in solid solution, behaves in a similar way to carbon from carbon monoxide: it concentrates the phosphide in the ferrite and eventually at 1,200 deg. to 1,300 deg. C. throws it out of the solid into the liquid solution, producing the ternary eutectic Fe—C—P, which appears in the globular form and as intercrystalline envelopes, and finally liquates out of the metal.

(6) The research opens the door for more investigation. The specimens experimented upon were very high in phosphorus, much higher than is permissible in any steel. It is proposed to make further trials with steels containing variable quantities of that element within the limits of 0.12 per cent. and 0.02 per cent., when associated with between 0.1 per cent. and 1 per cent. carbon.

Section II.

When this investigation commenced it was thought that the ranges of temperature at which phosphide of iron (Fe_3P) passed in and out of solid solution in iron would be as readily determined as the critical ranges at which carbide of iron passes in and out of pure iron, but instead it was discovered that, owing to the more inert character of the phosphide, such was not the case. The records which follow must be regarded as the result of a reconnaissance and scouting expedition into an almost entirely new, unexplored country, but nevertheless contain sufficient evidence to enable anyone to carry on future work more systematically. The illustration with descriptions given by the author, enable one to see at once the proofs of solution and dissolution.

What little work that has been done in the past on the crystallisation of Fe_3P from solid solution is recorded in various papers by the author, and the first indication or evidence of the temperature at which free phosphide could be induced so to crystallise was published in 1890, in which it was noted that on exceedingly slow cooling from above 1,200 deg. C. of an alloy containing about 2 per cent. phosphorus and 0.12 per cent. carbon, free phosphide of iron separated out between some of the cleavages of the iron crystals. Particulars are now given of the most recent investigations in that connection.

A series of alloys was selected, on which to experiment, including:—(1) A decarburised alloy from a Cleveland blast-furnace bear, which, although variable in different parts, contained free phosphide in envelopes round the crystals of iron and free Fe_3P in the body of the metal. (2) A Mexican meteorite containing rhabdite or free phosphide crystals. (3) Alloy of iron and phosphorus

* Abstract of paper, read before the Iron and Steel Institute, May, 1918.

made by adding phosphorus to white-hot puddled bar in a clay crucible. (4) A series of alloys containing between 0.4 and 2.2 per cent. phosphorus made by the Thermit process. These contained rather variable amounts of silicon, aluminium, etc. (5) Portions of the Cleveland decarburised bear free from independent phosphide of iron (Fe_3P) containing only traces of carbon and between 0.5 and 0.60 per cent. phosphorus in solid solution.

The first trials were made on the decarburised bear. After making a large number of trials by heating at various temperatures over long periods extending from six to twenty-eight hours, it was found that whilst no phosphide of iron passed into solution at 800 deg. C., at 850 deg. C. solution commenced. It may be expected, therefore, that with a solvent containing about 0.5 per cent. phosphorus, phosphide commences to dissolve at some point between 800 deg. and 850 deg. C. On heating to 960 deg. C. solution proceeds with considerable rapidity. In five minutes it is considerable, in fifteen minutes it is nearly complete. On long heating at 1,000 deg. C. the diffusion is perfect and the alloy homogeneous.

Having a specimen of a Mexican meteorite containing free crystals of iron nickel phosphide, or rhabdite, trials were made with it to find out at what temperature the crystals began to dissolve. The rhabdite began to dissolve at about 600 deg. C. on heating for twelve hours. As the heat was raised solution was very pronounced and rapid.

In the next set of trials a bar ½ in. sq. and 4 in. long was bedded in mill scale to remove the carbon, the scale being contained in a porcelain tube closed at one end. The closed end was inserted in the side of a muffle furnace heated to a temperature of 1,000 deg. C. each day during six hours. The hot end of the bar was heated to the point at which silver wire just melts, while the other end, which protruded out of the furnace, never attained a temperature above 500 deg. C. It was heated intermittently for sixty hours and then removed from the furnace. The bar was ground down on one side, and, after polishing, was etched and examined under the microscope, when it was found that in the parts most highly charged with phosphorus, free crystals of iron phosphide (Fe_3P) were present at all places where the temperature exceeded 660 deg. C. up to 900 deg. C. The crystals were exceedingly minute where they had formed at the lower temperature, but increased in size as the temperature rose, and were at a maximum at 900 deg. C. At about 800 deg. to 850 deg. C. the amount crystallised out was at a maximum, but at 800 deg. C. no crystals could be detected in areas originally occupied by the pearlite, which were now completely decarburised by the mill scale. Where the metal had been heated at 900 C. only in the metal adjoining the eutectic films, were there any free crystals, and at 960 deg. C. there were none. The metal at that temperature had become a homogeneous solid solution. There were no eutectic films. These observations show clearly that the temperature at which phosphide of iron (Fe_3P) falls out of solid solution depends upon the amount present.

In the fourth series the thermit metals were all heated in a muffle furnace for six hours at 1,000 deg. C. and then re-examined. The primary crystallites were no longer in evidence, and excepting in the alloys containing more than 2 per cent. phosphorus, the eutectic had also vanished and the metals had become homogeneous solid solutions. On re-heating the alloy containing 2.2 per cent. phosphorus to 1,050 deg. C. for a short time, and then for a longer time at between 960 deg. and 1,000 deg. C., a crop of minute iron phosphide (Fe_3P) crystals appeared. On reheating this same specimen for six hours at 800 deg. to 840 deg. C. the crystallites developed to a considerable extent. Another specimen, containing close on 2 per cent. phosphorus, heated to 1,000 deg. C. had no free crystals, but contained some undissolved eutectic. On heating at 820 deg. to 840 deg. C. for six hours new crystals developed freely.

In the fifth series sections were used cut through three columnar crystals of the Cleveland decarburised bear. One containing a total of 1.25 per cent. phosphorus was heated to 960 deg. C. for ten minutes, when it was found that practically all the free phosphide had dissolved, but was concentrated in solid solution around the traces of undissolved phosphide. It was then heated for several hours at 780 deg. to 800 deg. C., after which treatment it was proved that some phosphide had recrystallised round the original traces of the free phosphide. Another section was heated to 1,000 deg. to 1,050 deg. C. to produce a homogeneous alloy. It was then reheated for six hours at 820 deg. to 840 deg. C. Fine crystals formed at the junctions of the crystals and near to the junctions. The evidence here is that when pre-existing free phosphide exists, on heating to a temperature favourable for crystallisation the phosphide is primarily attracted to it.

Iron phosphide is a chemical salt, for, in its formation, when iron and phosphorus are brought together at a temperature of 1,000 deg. C., or above, chemical union is effected and is accompanied by considerable rise of temperature. There seems little doubt that it retains its identity after it dissolves in solid iron. The facts known about the behaviour of one of the most simple salts—sodium chloride—in water will enable one to compare them with the evidence advanced about the solution of iron phosphide in iron.

The rest of the Paper was devoted to pointing out the analogy between the behaviour of the liquid and solid solutions of iron phosphide on the one hand and of common salt on the other hand.

BRIQUETTING TURNINGS WITHOUT A PRESS.—A recent issue of the "Echo de Mines" describes a process of briquetting borings, turnings, etc., without the help of a press, as practised in a foundry at Cherbourg. About 220 lbs. of iron turnings from the lathe, etc., are spread on a platform and mixed with 9 or 10 lbs. of cement, moistened with 2¾ gallons of a weak solution of muriate of ammonia (about ¾ lb. of sal ammoniac to 22 gallons of water). The mixture is well turned over with shovels in the same way as concrete is mixed, and is then filled into wooden moulds (slightly tapered inside) about 8 in. in diameter by about 5 in. high, the finished briquettes weighing about 26½ lbs. each. The material is first tamped into the moulds with iron rods, and then well pounded with cast-iron rammers. After the material has set, the moulds are removed and the briquettes are left to dry. To make 700 briquettes a day, a working gang of one man and three women is required. The briquettes do very well in the cupola, and may be used in the proportion of 15 to 20 per cent. of the total charge. The cement goes over into the slag and causes no trouble. It is used also as a binder in some French foundries where there are no sufficiently powerful presses to produce briquettes without some binding material.

British Foundrymen's Association.

SHEFFIELD AND DISTRICT BRANCH.

At a meeting of the Sheffield and District Branch held on April 19, the President (Mr. John Little) in the chair, the following officers were elected for the session 1918-19:—President, Mr. J. G. Crowther; Senior Vice-President, Dr. W. H. Hatfield; Junior Vice-President, Mr. J. R. Hyde; Hon. Secretary, Mr. J. Dickinson; Auditor, Mr. W. H. Oxley. The election of Mr. Hyde as Vice-President left a vacancy on the Committee, to which Lieut.-Commander L. Jackson, R.N., was elected. Three members of the Committee retired in rotation, of which Messrs. C. Webster and H. Bagnall were re-elected, and Mr. F. Atkinson was chosen for the third place. The other members of the Committee are Mr. F. Darley, Dr. P. Longmuir, Mr. T. Brown, Dr. T. Swinden, Mr. J. Watson, and Mr. W. J. Dawson.

The delegates from the Branch to the General Council for the ensuing session will be Messrs. J. G. Crowther, J. Little, and J. Dickinson.

Annual Convention.

Mr. Little, remarking that the Annual Convention of the Association would be held in Sheffield on Friday and Saturday, June 21 and 22, said that owing to the war there had not been any Conventions recently, the Association simply holding a business meeting in London each year; but it was felt by the Council that rather more than that should be done this year, in order to keep the Association a little more lively. It had been decided to have three Papers on the Friday and three on the Saturday. Mr. T. H. Firth had undertaken to look after the social side of the gathering, and up to the present he had the prospect of giving them a fairly good time. It was not proposed to invite ladies, owing to the difficulty of arranging for trips into the country and other amusements.

Mr. T. H. Firth, speaking as the President Elect, said they would do what they could in Sheffield to make the Convention a success. He had applied to the directors of the largest steel foundry in the city for permission to go round the works on one afternoon, explaining that the Conference would be a munitions gathering; but the chairman of the Company thought they had better not. Other people, however, had been a little more kind to him. Without any application from him, Messrs. Thomas Firth & Sons had intimated that they would be delighted to receive the members on the Friday afternoon, and the chairman (Mr. Bernard Firth) said he would entertain them to afternoon tea. The Conference would start on the Friday morning with the election of officers. This business would be followed by the reading of Papers. Then they would have lunch, followed by a visit to Messrs. Firth's works. In the evening, they would probably have a dinner. The Lord Mayor had promised to attend the lunch if possible, but if he was unable to be with them on that occasion they would hope to have him at the dinner. On the Saturday morning they would have further Papers.

Mr. J. G. Crowther, the new President, then proposed a vote of thanks to Mr. Little for the services that he had rendered during the past two years. Mr. Firth seconded, and Mr. T. Brown supported, and the resolution was carried unanimously.

Pipe-Casting Difficulties.

Mr. Little, having suitably responded, the meeting resumed discussion on a question raised by Lieut.-Commander Jackson, R.N., at the December meeting, as under:—"Why is more difficulty experienced in casting a plain cylindrical pipe in cast steel, say a knuckle or ball joint length of from ¼-in. to 1½ in. in thickness, and from 8 in. to 12 in. in diameter, in comparison to an intricate marine control valve or expansion piece in cast steel?"

Mr. T. Brown said that since the December meeting his firm had had an order for some of the particular pipes referred to. He tried a new method of casting them. He had a pattern made, and lengthened it with a feeder, and cast it on its end, with a runner into the bottom and the runner spinning. He thought that would keep the steel spinning all the way to the top. But when the casting was machined he found that, although it was perfect up to a certain height, above that position it had the same faults as before. He had come to the conclusion that this was due to nothing but the hot steel running into the bottom not spinning towards the top, owing to very quick solidification in this part of the casting. Mr. Brown illustrated his remarks with a sketch on the blackboard, and also produced some test pieces from the pipes to show the faults.

Mr. H. Bagnall suggested that the difficulty might be overcome by using several ingates at different heights in the casting. This would keep the metal fluid just at the point of contact with the casting.

Mr. Brown said the suggestion was a very good one. But he had tried running with five or six ingates on a casting, and he had always found that the bottom runner took all the metal, as long as it was fluid.

Mr. Bagnall said that with certain castings, which had not to be machined, there was a difficulty caused by their striking off rough on the outer facing. With a series of runners such as he suggested he had had a casting perfect in appearance. That proved to him that the metal had not all gone in at the bottom. He was speaking of cast iron.

Mr. Firth said he did not know anything about the temperatures at which the castings in question were run, but he knew that, in running a chilled roll in cast iron, if they had the metal the slightest bit cold—in fact, if they did not keep it very hot—they would have that kind of defect on every roll that they made. If they did have a roll that was the least bit pin-holey they knew in a second that the only reason for it was that it had been run cold. He should think that Mr. Brown's greatest difficulty probably was that the metal was not hot enough.

The President said if Mr. Bagnall thought the defects were due to the metal chilling in rising up the mould, and that running at different heights would cure this, how did he account for the fact that both the top and the bottom end of the casting had the same faults?

Mr. Bagnall: In the case where it was run from the bottom, it was faulty at the top; but in the case where it was run from the top, of course, I could not explain the reason.

Mr. Brown said the castings he had mentioned were porous all through.

The President said then he should be very much inclined to adopt Mr. Firth's view, and say that the casting temperature was wrong. The greatest

number of wasters were caused by running at a wrong temperature.

LIEUT.-COMMANDER JACKSON, R.N., pointed out that the difficulty was only found in this one particular kind of casting. There might be a dozen or two dozen other castings made from the same heat, and they would be all right. It was only when they came to this kind of casting that they had the trouble. He thought that rather told against the temperature theory.

MR. FIRTH, in reply, said the other castings were not of the same shape. In the case in question, they were trying to spin, and unless the metal was very hot it would not spin. It was the spinning that was wanted in order to get the gas and dirt away. With chilled rolls, unless the metal was very hot, they would never get one right.

MR. F. DARLEY said his experience was that, not only in a ball pipe, but in anything of the shape of a ram, bad places were invariably got on the outside. In a cylinder that was bored the full length, they were not found, but in rams that were machined all over very rarely was one got perfect. He referred to those that were machined on the outside only—in cylinders that had to be machined the full depth there was no difficulty, as a rule, in getting them perfect. He believed that when the castings under discussion were first taken on they were cast on the flat, and several turned out good. But although the same methods were tried again, the faults occurred. Some of the firms requiring them were so anxious about them as to have them made out of a solid ingot, bored out and machined all over. Others had made them of gunmetal, but they did not care for gunmetal.

MR. W. SHEPHERD remarked that where there was a projection, or other impediment to running, there was always a difficulty in getting a casting clean. The metal was, he thought, very apt to be throttled there, and any refuse or gases were likely to stay there. He suggested that the casting should be made straight on the inside, and only the ball part bored out. Of course, this would add materially to the expense.

THE PRESIDENT said that steel was not the only metal where the same trouble was found. It occurred in the case of copper, but there, undoubtedly, it was due to the metal. To-day there were people who made solid castings in copper in order to get solid cylinders.

LANCASHIRE BRANCH.

The general meeting of this Branch was held on May 4 at Manchester, Mr. A. Key presiding. The report for the year was read by the secretary, Mr. Hogg. He stated that the total membership of 180 comprised 43 Members, 112 Associate Members, 25 Associates, the increase on last year's figures being respectively 6, 18 and 1. Seven meetings of the Branch had been held, and visits had been made to the works of Messrs. Chadwick, of Bolton, and Messrs. Spencer & Cook, of Stalybridge. Owing to the war conditions the annual dinner was not held. The total income, includng £2 2s. 6d. balance from the previous year was £29 2s. 6d., and the local expenditure £17 12s. 11½d., leaving a present balance of £11 9s.

The election of officers resulted as follows:—President, Mr. S. Roe; Senior Vice-President, Mr. W. H. Meadowcroft; Junior Vice-President, Mr. J. Haig; Auditors, Messrs. H. Grandridge and J. Nicholls; Secretary, Mr. J. Hogg; Delegates to General Council, Messrs. H. Sherburn, J. H. Simkiss, A. Key; Branch Committee, Messrs. W. H. Meadowcroft, A. Hill, J. Wittham, C. Bickerton, G. Barnes, J. Masters, A. Sutcliffe, and Miles.

A vote of thanks to the officers and committee for their services during the past year was carried.

A discussion on "The Burning of Castings," which followed, will be dealt with in our next issue.

Claims for Electric Steel.

Mr. J. A. Mathews, in a Paper presented to the American Electro-chemical Society, advanced the following claims for electrical steel as demonstrated by exhaustive experiments:—(1) The chemical composition of consecutive heats, most notable when handling easily oxidisable metals like vanadium, chromium, silicon and manganese, can be held more closely to a standard than with any other process. (2) To insure a given final minimum, less of these metals need be added; hence there will be less of the oxides of these metals produced in the steel and less to be removed. (3) Successful heat treating is improved according as composition can be controlled. (4) Electric steel usually is chemically purer than any other steel. If the segregation of sulphur and phosphorus are not to be feared, as they are absent, the percentage of cropping may be reduced and the yield of sound metal increased. (5) Low sulphur in electric steel usually indicates a prior reducing condition favourable to complete deoxidation, sound ingots, freedom from blowholes and resulting seams. Quiet metal has less tendency to segregate in the mould, in respect to either metallic or non-metallic elements, and produces steel free from laminations. (6) Alloy additions may be made in the furnace itself rather than in the ladle, which increases the probability of thorough assimilation, diffusion and homogeneity. (7) Results indicate that electric steel is less easily injured by overheating than other steels. It has a wider heat range and will withstand variations in forging and heat treating without injury. (8) Electric steels are usually freer from slag and non-metallic inclusions than Bessemer and open-hearth steels. (9) The electric furnace possesses an economic value in its adaptability to the recovery of scrap, and has decided advantage over the open-hearth furnace in that some alloy scraps do not make desirable additions to open-hearth furnaces, or if such additions are made, usually result in a great deal of the scrap metal being lost in the slag. With the widespread and increasing use of alloy steels it is highly desirable that alloying elements contained in the scrap should not be lost.

THERMO-MAGNETIC PROPERTIES OF CARBIDES IN STEELS.—Messrs. Honda and Murakami have investigated the thermo-magnetic properties in carbides found in certain steels (Krupp, Swedish, and Yawata tungsten steel), and summarise the results of their investigation as follows:—(1) Iron cementite is ferro-magnetic whose specific magnetisation in a field of 500 Gauss is 13.7 (2) The critical temperature of cementite is 215 deg. C. (3) In its free state the cementite is almost wholly decomposed into its components by heating it to 900 deg. C. for a sufficiently long time. (4) The double carbide in low-tungsten steels is also ferro-magnetic whose specific magnetisation in a field of 500 Gauss is 15.5. (5) The critical temperature of double carbide is 400 deg. C. (6) In its free state the carbide decomposes into its components by heating it to 850 deg. C.—"Science Reports of the Tôhoku Imp. University.

THE DAVIS FURNACE COMPANY, Diamond Foundry, Luton, Beds., have issued an illustrated catalogue (D.P./18) of their gas-fired and oil-fired furnaces, showing some important features of the demonstration plant at the Diamond Foundry.

Correspondence.

"Autogas" Gas Producer.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—In the excellent article in your issue for May, 1918, describing our "Autogas" gas producer, we notice that towards the end of the third paragraph the following sentence occurs:—"The producer works satisfactorily with a pressure of ½ in. W.G., so that with a chimney ventilation no induced draught is required."

We should be glad if you would kindly note that the word "pressure" should, of course, be "suction." Our whole aim in designing this producer has been to make it as simple as possible. Air under pressure would entail the use of a fan. Perhaps you will please publish this correction in your next issue?—Yours faithfully,

A. D.

Essex Works, Aston, Birmingham, May 18, 1918.

Foundry Practice and Increased Production.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—A question of great importance is that of industrial reconstruction after the war. Changes have taken place which must effect all, but to what degree are they going to operate in the foundry? There will probably be a great demand for products of all kinds, and we are constantly being told that there must be a greater production than in pre-war times. How is this problem going to be met and solved in the foundry? The wastage in human life, the taking away of youths and young men from the shops, will cause a real shortage of skilled moulders. The good workmen will go to the best employer, who in return will have the best results.

Much is said about standardisation of work and it being performed by unskilled and semi-skilled workers. This may apply to work simple in design, or where there is a large quantity required to compensate for the extra capital used to provide the necessary tackle. That branch of the founding usually called jobbing work is the one most difficult to treat in the problem of increased production. Inventions and improvements in machinery will make it that moulding will always remain a craft, dependent mostly on the skill of the moulder.

Some system of payment by result should help to bring about increased production, this system being the only one that will give to the worker the greatest incentive to produce more castings. Also, if employers would keep in personal touch with their works and see that the machinery is used to its limit and is up to date, and judge how far mechanical means can be used to lighten the hard manual work of his workers, a great improvement would result. They should take as much interest in the process of production in the foundry as is taken in the drawing-office and machine-shop. The employer never expects his fitter to work without hammer and chisel and file, or his machines to run smoothly under a leaking roof; but he expects moulders to produce castings economically with a scarcity of tools to work with. Many moulders have to confess at the end of a hard day's work that the search round for such things as rammers, vent-wires, riddles, lifters and other necessary material has been more tiring than the process of moulding. Greater production can be got in keeping the moulder moulding, and not spending part time as fitter, joiner or labourer.

Another disturbing factor is the want of tact by some foremen. Having gained a post of trust, the foreman will sometimes completely isolate himself away from his fellow-workers and take up an attitude of superiority towards them that kills the freedom to discuss the best methods of production, and so make his most sensitive workers sullen and indifferent. Moulding must always be dirty, unattractive work. More is the reason that every effort should be made to keep the shop clean, with good lights, well ventilated, and warm in cold weather. Moulders, like other human beings, will respond to favourable conditions. It is along these lines or similar that increased production will have to come. Any moulder competent to judge knows it will not have to come out of his muscle, with the unfavourable conditions of foundry life as they exist to-day.—Yours, etc.,

Gorton, Manchester. G. E.

Types of Cupolas.

To the Editor of the FOUNDRY TRADES JOURNAL.

SIR,—The writer has read with considerable interest the Paper read to the Lancashire Branch of the British Foundrymen's Association, on "Types of Cupolas." Again the fact is emphasised how little attention is paid to that very important part of the foundry practice, the proper construction and management of the cupola, and, in passing, I would remind you and your readers that whilst it is desirable that names of makers of cupolas should not be mentioned in either lectures or Papers, it should also be borne in mind it is very unfair to name tools of foreign make which are in competition with manufactures in this country.

No type of cupola will be a success unless all other elements are up to concert pitch, and I think it will be generally agreed that many old boilers stood on end have given good account of themselves when everything else connected with the melting of iron has been of a high standard and quality. The fan or blower, tuyere size and position, size and shape of blast pipe, quality of coke, etc., all play a very important part; but perhaps the most important is intelligent management in working, the shape of lining, size at various given points, method of charging, etc. These all have an effect either one way or another on the results obtained.

One gathers on reading the report that some disappointment was felt because more encouraging advice was not forthcoming on a more economical working to meet present-day advanced prices of coke, and on this point the writer is of opinion the subject should receive a continuance of investigation.

Whilst the members of the Lancashire Branch seem to think that 20 cwt. of iron melted with 1¼ cwt. of coke would be good melting, the writer has actually melted 20 cwt. of iron with 1 cwt. of coke repeatedly, and in different localities, with British-made cupolas. There are none superior when properly handled and provided with suitable auxiliary plant.

It is therefore to be hoped the B.F.A. will continue the research until some sound formula can be devised for the relief of the greatly worried and very much abused foundryman.

J. J. MCCLELLAND.

262, Victoria Park Road, London, E.9,
May 17, 1918.

BLACKMAN EXPORT COMPANY, LIMITED, 374, Euston Road, N.W.1, have forwarded an illustrated leaflet relating to a new type of ventilating fan blade, known as the "War-blade," composed of a tough, non-metallic fibrous substance.

Dish-Cast Ingots.

By JOHN A. HOLDEN.

The production of steel ingots which will work up into bars and billets free from defects is by no means an easy undertaking. The process of manufacture may have some bearing on the quality of the steel, but defects such as pipe and cracks are common to all processes. Steel made in the electric furnace is no exception to this statement. As the available temperature is extremely high, it is perhaps not surprising that electrically-melted steel does not always reach the anticipated standard of excellence. Unfortunately no method of determining the temperature of liquid steel has been evolved which is reliable and capable of withstanding the conditions of furnace application.

The temperature of casting no doubt deserves some of the criticism it receives. Where the operations are controlled by the furnaceman "hot casts" are more prone to be made than "cold heats." As the men are often paid in proportion to the weight cast, they are chiefly concerned with teeming all the steel from the ladle. The simplest way of filling an ingot mould is to teem direct from the ladle, the method commonly known as "top-running." With certain steels the ingots may be free from cracks; with others the results speedily convince one that simplicity is its only commendable feature. High-carbon steel may be cast in the manner indicated and teemed hot enough to give a pitted surface, yet there would be a very small risk of cracked ingots. On the other hand, the percentage of "pipe" would reach serious dimensions.

Moulds which are filled with the wide end uppermost, and fed through a fireclay nozzle or feeder head, yield the least amount of scrap through "piping." The author made two casts of steel of almost identical composition, using 12-cwt. moulds of similar pattern for both heats. The first cast was dish-cast with the narrow end uppermost. One of the ingots was broken, and it was found that the secondary pipe terminated 2 ft. from the ingot top, equivalent to 44 per cent. of the length of the ingot. The second cast was teemed into moulds with the wide end uppermost. One ingot was sawn horizontally across at a distance of 4 in. from the top. In this case the pipe terminated at 7 in. from the ingot top.

As bottom-run ingots are usually cast in groups, each mould is necessarily filled very slowly, and it is well known that such ingots are much less liable to crack than similar steels top-run direct from the ladle. Further, ingots of the former class usually have a clean surface, which is smooth except for ripple marks.

Mr. Kilby states that bottom-cast ingots are prone to contain fluxed runner brick.* The writer can confirm this statement. An analysis of a slag globule taken from the runner immediately under the ingot agreed in the silica percentage (the quantity obtained was very small, and not sufficient to make a complete analysis) with the silica content of the runner bricks. The steel in question was "basic" electric, and very low in carbon (0.09 per cent.).

The effect of dish-teeming is to fill the moulds very slowly, because the dish reduces the size and the velocity of the stream. There is no doubt that temperature determines the viscosity of steel; the writer, however, has not made any comparative tests on these lines. In passing through the dish the steel cools considerably; so much so that an inexperienced eye can see the difference. But dish-teeming gives a splashed surface, and as appearances have some commercial value, this operates against it. The writer has found that the effect of the splashes are almost negligible. This applies with equal force to alloy steels.

Below is given a series of casts showing the results obtained with various steels and methods of casting. The dish-casting was suggested by Mr. J. M. Kilby's Paper. The casts of steel were all electrically melted.

Nickel-Chromium Steels (Nos. 1, 2 and 3).

No. 1.—Top Run.

Size of nozzle in the ladle.	Pit.	Results.
¾-in. ...	Six 12-cwt. size moulds.	First two ingots cracked horizontally; remainder free from cracks. Surface fairly good: sixth ingot lapped. Speed of teeming—1st ingot, 90 secs.; 6th ingot, 120 secs.; skull in the ladle, 1½ cwts.

No. 2.—Bottom Run.

1¼ in. ...	Six 12-cwt. moulds set radially round the trumpet.	Ingots free from cracks; surface lapped near the top; otherwise good. Speed of teeming, 4 minutes.

No. 3.—Dish-Teemed.

1¼ in. ...	Six 12-cwt. moulds. Three two-way dishes; 1-in. nozzles throughout.	Ingots free from cracks, surface splashed. Average of 2½ mins. for teeming each. Yielded very satisfactory billets

No. 4.—0.10 per cent. Carbon Steel.

1¼ in. ...	Six 12-cwt. moulds. Three two-way dishes; first two ¾-in. nozzles: Remainder 1-in.	Ingots free from cracks; surface splashed. Billets required very little chipping.

No. 5.—1.00 per cent. Carbon Steel.

1¼ in. ...	Six 12-cwt. moulds Three two-way dishes; 1-in. nozzles throughout.	Surface splashed. Ingots yielded 89 per cent. of the weight as billets.

The same pattern moulds were used throughout. Cheek bricks were used to form a feeder head. The cracked ingots obtained in No. 1 cast were free from "fash," and the stream did not "wipe" the mould. The results obtained were confirmed in a subsequent cast.

STEEL IN BRAZIL.—The first successful manufacture of commercial steel in Brazil was recently accomplished in the Engenho de Dentro works of the Central Railroad of Brazil, Rio de Janeiro. Native pig-iron with a mixture of about 40 per cent. scrap iron, without any steel scrap was used, and a steel converter having a capacity of 1 ton. The native pig used, on analysis showed the following percentages: — Silicon, 1.645; carbon, 3.50; phosphorus, 0.09; manganese, 1; sulphur, 0.02.

* "Steel Ingot Defects," by J. M. Kilby. *Journal of the Iron and Steel Institute*, 1916 and 1917.

Speeding Up Foundry Work.

To-day the foundry is playing by no means the least important part in the production of munitions, and a speeding-up of production has been generally adopted. In most instances, however, the installation of labour-saving machinery has been wholly responsible for the increased production, and apart from the change of operations which has been made imperative with the new machinery, the foundry methods and practice have remained as heretofore. Indeed, we are so accustomed to regard modern machinery as the one and only means of increasing production, that we are apt to overlook the equally important questions of system and organisation.

Labour-saving machinery is, of course, wholly desirable, but we cannot expect to get the best out of such machinery unless its use is governed by a carefully organised system. At the present time it is difficult, if not actually impossible, to obtain new machinery, but even in an old works and with an old plant it is remarkable how much can be accomplished by the employment of a carefully thought-out system of organisation.

Our representative had striking evidence of what can be done in this direction when he recently paid a visit to the Derby works of the Derwent Foundry Company, Limited. As a matter of historical interest this is amongst the oldest of such works in the country, being established in Sheffield in 1801, since when it has always been under the control of a member of the Jobson family—Mr. Vincent Jobson is the present managing director. It is interesting to note that during the Crimean war the Government allowed the works to issue their own tokens (value 2d. each). The works were transferred to Derby in 1849, and removed to their present site in 1865, whilst in 1889 the business was converted into a limited-liability company under its present style.

Prior to the outbreak of war the staple production of the company was stove grates and general light castings for the trade. The war incidentally led to an abnormal demand for cast iron capable high-speed machining. It was in this direction that Mr. Jobson at once commenced to develop, and he has succeeded in evolving a special mixture, which can be constantly maintained, and by which is produced a light grey casting which can be machined at the rate of 100 ft. per minute; in fact no castings for machining are allowed to go out of the foundry which exceed 35 deg. scleroscope hardness. Such was the demand for this material that the company was wholly unable to meet it, although for some months the floor was cast off four times in the twenty-four hours, *i.e.*, twice in the day and twice at night.

The foundry, it may be mentioned, is an old one, and by no means convenient, but by a system of standardisation of the work and encouraging those employed to take an intelligent interest in their work, the output has been actually trebled. As a matter of fact, every 1,000 ft. of floor space in the foundry produces 6.5 tons of light castings per week working day shift only, whilst it may be here mentioned that this is the only foundry in Derby working a 48-hour week, and, further, the girls and women, who throughout the works form 60 per cent. of the employees, are allowed 10 minutes for lunch and 10 minutes' interval in the afternoon.

Formerly the whole of the work was hand moulded; recently, however, a number of hand-operated squeezing moulding machines have been put down. Everything is flask moulded, and all flasks are inspected daily. It may also be noted that all patterns are built up of split halves.

Practically everyone employed has been taught on the works, and in this connection the core shop is a revelation, young girls producing cores for hand grenades at the rate of 180 per hour, the cores, the making of which takes 31 movements of the hand, being turned out in 16 seconds. In the foundry each moulder does his own casting; the moulds are, however, stripped and the castings cleared by labourers.

A system of instruction cards has been drawn up showing the standard time in which each unit operation in all jobs should be completed, and the operators are taught to do it in the manner laid down, when, of course, it cannot fail to be completed in standard time; and they are paid high wages for working according to the methods of the management. The standard time is set scientifically by time study, and is regularly beaten by all operators after training in standard methods. Thus it will be seen that all operators doing the same job do it in exactly the same way. If the employers make an error in setting a standard time and it goes against them, they do not reduce it, but look upon it as a warning to them to get to know more about their own jobs; whereas if an error is made against the operator it is adjusted at once, the principle being to cultivate confidence and a spirit of always giving a "square deal." We reproduce the card (A) which has to be filled up for each machine daily. In addition to which a daily report (B) is filled up by the foundry manager. On the back of this card are stated the compositions of the charges.

It will be seen from the foregoing that the whole of the work is examined before passing out of the foundry, and whilst being so examined a percentage of each cast is sent to the office for testing and to the machine shop, in which last the work is put through a standard operation, new tools in each instance being employed so as to give a relatively constant factor. The report of the workman who does the machining is then handed in to the office and read in conjunction with the hardness test. In this connection it may be mentioned that at the time of our representative's visit a shop report had just come in on which was the remark "castings hard." The batch referred to showed by test 35 deg., and the explanation furnished was that the guarantee provides for not greater hardness than 35 deg., the actual hardness being from 33 deg. to 34 deg., and that having such a low hardness figure as standard, what their own machine shop calls hard other machinists would call soft. The firm say that their own machine shop is "spoilt" by not knowing what some machinists have to put up with.

The work from the foundry passes to the fettling shop, which is equipped with emery wheels. It is checked as it goes in and examined as it passes out to the machine shop.

Each batch of 25 castings going through the machine shop has a card (see Card "C") which is filled up by the inspectors. Above each machine is a card with the headings "Time," "Wanted," "Got," "Waste," the last two items being filled in by the inspector every hour. One of the opera-

tions upon the parts being made furnishes eloquent testimony as to the quality of the material. This consists of cutting a thread on a shoulder 2 in. in dia. by 1 in. long, 14 threads to the inch, a perfect thread being produced in 43 seconds, the cutting speed being 80 ft. per min. All plain turning is done at a minimum of 100 ft. per min.

Cards are filled in for each operation, the cards in every case being filled in by the inspectors responsible for the particular operation, and these are all entered up in the works' log against the operator's name.

It will be seen from the foregoing that whilst nothing is left to chance, there is an entire absence of complication, which, in many so-called systems, acts as pin-pricks upon the workmen engaged.

Of course, additions had to be made to the melting plant, and as it was not possible to obtain delivery of a cupola, the company built one for themselves out of an old boiler. A piece of stovepipe has to do duty for conducting the blast, but for some months the improvised cupola has been bringing down 30 cwts. of metal per hour.

Name..... Number.....
Machine No. ..... Job No..... Date.....
Boxes made..... Boxes Cast.....
Should produce good .....
Actual good .....
Waste .....
Waste per cent. on "should produce "..... .....
Instructor..... Works Manager .....

This Card to go out with Castings to Dressing Shop and be filled in as soon as Castings are inspected and handed to Instructor.

INSTRUCTOR'S NOTES ON BACK.

A.—MOULDER'S CARD.

DAILY FOUNDRY REPORT. *Date*.....

	Tons.	Cwts.	Qrs.	Lbs.
Iron charged				
Coke charged				
Iron melted per ton coke				
Poured down				
Good castings				
Waste castings				
Sprues				
Total accounted for				

Discrepancy with iron melted=

Waste castings as per cent. on Good plus Waste= %

B.—FOUNDRY MANAGER'S REPORT CARD.

Operation 3.		5600		5600
Name	No.			
Good	Waste	Fdy.	M/C.	OPERATION 3.
Inspected by				

C.—OPERATION CARD.

Ryland's Directory.

RYLAND'S DIRECTORY OF THE COAL, IRON, STEEL, TINPLATE, METAL, ENGINEERING, AND ALLIED TRADES.—London: Eagland & Company, Limited, 165, Strand, W.C.2. (Price 35s., cloth, net.)

The 1918 (or Fourteenth) edition of this standard work of reference is considerably larger than any of its predecessors and comprises 1,748 pages of invaluable information relating to the "key" industries, not only of Great Britain, but all the Allied countries. The new edition is of particular importance at the present juncture, bearing in mind the fact that a large number of firms have varied their specialities and embarked upon the manufacture of entirely new lines whilst the war has been in progress. Also many firms who were previously quite outside the scope of the trades covered by "Ryland's" have, either by converting their existing plant or laying down new machinery, become entitled to a place in the book, which has long been recognised throughout the industry as the *vade mecum* of both buyers and sellers.

In the first section of the volume full particulars are given in alphabetical order of 17,000 firms. The information given is very comprehensive, and in the case of limited liability concerns includes the names of directors, secretary, amount of capital, and in the public companies, the dividends for the last five years, debentures, etc. Many changes in the directorates of companies, amalgamations, and interchange of capital have taken place within recent years, particularly in the iron, steel, and coal industries, and these have been duly noted in each firm's entry, so that the reader is able to see at a glance if a firm is interested in any other companies. We also notice in this section of the book a welcome amplification of the trade description. As a case in point, the chief specialities of manufacturing engineers have been added, and it is indicated if firms specialise as colliery, marine, etc., engineers.

The geographical section forms a classification of the firms enumerated in the alphabetical part, but in county and town order, and in large towns, also in street order. This portion of the book will be found a very handy and useful guide to sellers and buyers working the country by districts.

Following the geographical section is that dealing with the classification of trades. The engineering industry, in all its branches, appears to have been exhaustively dealt with, and we notice a very large number of new headings in that part of the book covered by "Engineers' Specialities." The foundry section has been extended by the inclusion of separate lists of makers of holloware, wrought sheet ironware, ranges, stoves, and the like. Heavy hardware is also given more prominence, and many specialities which are usually associated with Birmingham and Sheffield are detailed. A new feature, which should be found exceedingly useful, is the non-ferrous metal section. Taking copper as an example, we find lists given of the copper ore mine-owners, followed by smelters and extractors, refiners, coppersmiths, castings, right away down to the rolled article, sheets, tubes and bars, wire, etc. The other metals are dealt with in a similar fashion.

The section devoted to the iron and steel makers is even more comprehensive than in previous editions. Commencing with tabulated lists of pig-iron makers and analyses of different brands, Bessemer and open-hearth steel-makers, steel-makers by the electric process (quite a long list now), and crucible steel makers, we note a new and separate list is given of high-speed tool-steel makers and their brands, which should be found of great value to buyers.

One of the valuable points about this book is the care and discrimination which has been exercised in distinguishing between the actual maker and the agent, and the compilers of "Ryland's" claim that users will not find they have wasted both time and money in endeavouring to do business with those who are not what they are represented to be.

Iron and Steel Institute.

The annual meeting of the Iron and Steel Institute was opened at the hall of the Institution of Civil Engineers, Great George Street, Westminster, London, S.W., on May 2. At the outset Sir William Beardmore (retiring President) presided.

Report of Council.

The Council, in submitting their Annual Report of the progress of the work of the Institute for the year 1917, recall that at the Autumn Meeting on September 20, 1917, Sir William Beardmore, Bart. (President), announced that the Council had nominated Mr. C. P. Eugène Schneider (Managing Director of Messrs. Schneider & Company, Le Creusot, France) for election as President at the Annual Meeting in May, 1918. The notice of Mr. Schneider's acceptance of the office was received with much gratification. The Council also announce that Mr. Alexandre Pourcel (Bessemer Medallist) has been elected an Hon. Vice-President of the Institute.

Roll of the Institute.—One hundred and forty new members were elected during the year, and to the new class of Associates, the formation of which was announced in the last Report of Council, there were admitted fifty-six. The total membership of the Institute on December 31, 1917, was:—

Patron	1
Honorary Members	6
Life Members	65
Ordinary Members	1,866
Associates	56
Total	1,994

There have been twenty-three resignations of members during 1917, and the names of six members have been removed from the list owing to the non-payment of subscriptions.

Honours Conferred upon Members of the Institute.—The Council have had occasion to congratulate a number of the members upon whom various honours and distinctions have been conferred during the year.

Finance.—The statement of accounts for the year 1917 has been verified in the usual manner by Messrs. W. B. Keen & Company, the auditors of the Institute, and is now presented to the meeting by the Hon. Treasurer. The accounts show that the total receipts of the Institute, excluding the income of the Carnegie Research Fund, were £5,427, and the ordinary expenditure was £5,202, leaving a balance of £225. The reduction in the receipts of 1915-16 was mainly due to the removal from the list of the names of members of enemy nationality, and it is gratifying to note that the effect of those measures upon the finances of the Institute has been only of a temporary nature. As large a sum as possible of the accumulated funds of the Institute was invested in the War Loan in the early part of the year. The receipts on account of the Carnegie Research Fund were £1,054, and the expenditure was £764, the surplus income over expenditure being £290.

Grants to Other Associations.—An Association for Research on Refractories is in process of formation. On the Organising Committee, of which Sir Richard T. Glazebrook is the Chairman, the Institute has been represented by Sir William Beardmore, Bart., President; Sir Robert Hadfield, Bart.; and Mr. Cosmo Johns. A draft prospectus has been prepared, and when approved by the Department of Scientific and Industrial Research will be issued to manufacturers and users of refractories, to universities and professional societies, and to certain trade unions, with an invitation to affiliate themselves with the Association. The Iron and Steel Institute has contributed £25 to the preliminary expenses of the Organising Committee.

In answer to an appeal from the Engineering Standards Committee to join in raising a fund for the purposes of extending the scope of the Committee's work in foreign countries, the Council has voted the sum of £500 as a contribution to the fund in question.

The sum of £50 was also voted last year to the Board of Scientific Societies to assist that body in carrying on its work.

Andrew Carnegie Research Fund.—One Report, recording the results of a lengthy research by Mr. J. H. Whiteley, on the Eggertz colour test for combined carbon, was published in 1917. This forms vol. viii. of the Carnegie Scholarship Memoirs for the year. Six new applications for grants were received, and awards were made to the following:—Mr. F. Bainbridge (Skinningrove), £100 for an investigation of the effect of fluorspar on the solubility of basic slag; Mr. W. C. Hancock (London), £50 to enable him to continue his investigations on refractory materials, with special reference to materials for coke-oven and furnace construction; Messrs. J. L. Haughton and D. Hanson (National Physical Laboratory), £100 to enable them to continue their joint research on the iron-phosphorus and iron-carbon systems; Mr. J. E. Hurst (London), £100 for an investigation of the wearing and microstructure of worn cast-iron specimens; Messrs. J. H. Whiteley and A. F. Hallimond (Middlesbrough), £100 for a joint research on the chemical determination of strain in iron and steel.

Committee Work.—During the year, meetings have been held by the several Technical Committees as follows:—Committee No. 1, for Ores, Fuel, and Refractories, has met twice; Committee No. 2, for Blast-furnace Practice, three times; Committee No. 3, for Steel and its Mechanical Treatment, four times; Committee No. 4, for Iron and Steel Foundry Practice, twice; and Committee No. 5, for Metallography, Chemistry, and Physics, and its Sub-Committees, six times.

Committee No. 2 has conducted an inquiry into certain points connected with blast-furnace practice in this country, the results of which are embodied in a report to this meeting. An inquiry into "Practice and Economies in the Use of Blast-furnace Gas" was also made, and the information collected is being dealt with in a report by Mr. A. Lennox Leigh.

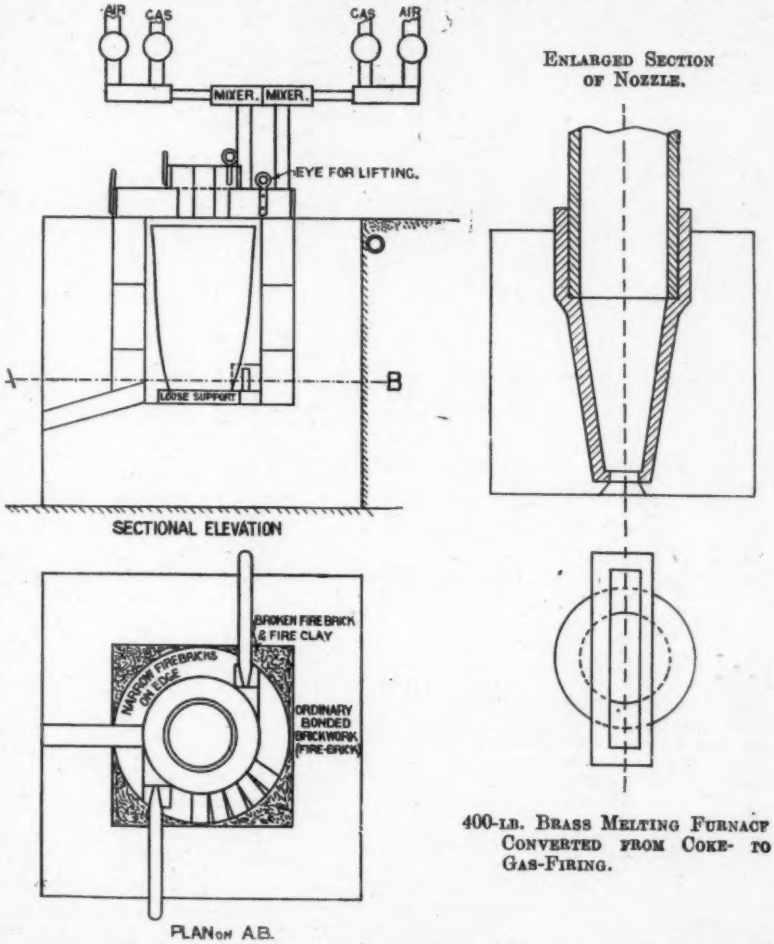
Committee No. 3 instituted an inquiry into certain points in connection with steelworks practice, and presented two preliminary reports at the Autumn Meeting. The Committee has in hand further work, which it is hoped will form the subject of a complete report at the next meeting.

Committee No. 4 has co-operated with the Forging and Castings Department of the Ministry of Munitions on the subject of the manufacture of malleable castings, and presented to the Department two reports, by Dr. W. H. Hatfield and Messrs. E. Adamson and J. E. Fletcher respectively, both of which are published in the last number of the "Journal." The Committee has also been inquiring into the present position with regard to steel-foundry practice in this country.

Converting Crucible Furnaces from Coke to Gas Firing.

The advantages of the gas-fired crucible furnace are generally recognised, but it seems to be an accepted idea that to be fired with gas the furnace must be expressly designed for that duty, and whilst there can be no doubt that the gas-fired crucible furnace of standard design will give more uniform results and possibly also prove more economical in operation, it is a sound commercial proposition to effect the change-over from coke- to gas-firing, and that with very little structural alteration.

Such a change has indeed recently been made at the works of the Atlas Brass Foundry, Gateshead-on-Tyne. Originally constructed as a six-hole coke-fired furnace for 400-lb. pots, three of the holes have now been converted to gas-firing. It will be seen from our illustration that beyond packing and providing a loose support for the crucible, no structural alteration has been required. Mr. A. B. Roxburgh, superintendent of sales, Gas Department, Newcastle-on-Tyne, was responsible for the design of the burner, the nozzle, and the general layout, the work being carried out by the Gas Department. It will be noted that the nozzle has been specially designed with a view to simplifying renewals; being carried between two bricks, which are cut to shape, it can be readily taken out and replaced.



400-LB. BRASS MELTING FURNACE CONVERTED FROM COKE- TO GAS-FIRING.

The gas and air, the former at mains pressure and the latter at a pressure of 2 lbs., feed into a vertical tube (air on top); the mixture is effected at the bottom of this tube, which forms a pocket and passes off through a horizontal tube placed at some distance from the bottom of the vertical tube, into the crucible chamber. Air blast is supplied by Keith-Blackman compound fans, which will be equal to the full duty of the six holes when the full change-over is made.

Starting from the cold with a 2-cwt. charge of gunmetal, the metal was ready to pour in 1¼ hours, which compares with approximately three hours in the side-by-side coke-fired furnace.

High Tungsten Alloys.

A patent has been granted in the United States to Messrs. Hans Goldschmidt and Otto Weil (assignors to Goldschmidt Thermit Company) for a method of forming high-percentage tungsten alloys. These are usually produced in electric furnaces, and hence contain a percentage of carbon, sometimes prohibitive for certain uses. Former attempts by alumino-thermic reactions were unsuccessful, causing large slag losses of the refractory tungsten, but good yields by the latter method were obtained by adding indifferent substances to the reacting mixture, such as lime or fluor-spar, in quantity up to one-quarter of the tungstic oxide used. (Purified scheelite may evidently also be used.) This process may be employed for incorporating tungsten or its alloy into molten metal baths, by merely adding a mixture of ferric oxide, tungstic oxide, aluminium and lime. The pure ferro-tungsten produced immediately alloys without waste, and the slag remains liquid on the surface of the bath. The method is claimed to be superior to that of adding pulverised metallic tungsten or ferro-tungsten in that no carbon or oxidised impurities are added to the melt, and the waste in non-alloyed tungsten is much reduced.

Deaths.

THE death took place recently of Mr. P. D. Atkins, manager of the Elba Steel Works, Gowerton, of Baldwins, Limited.

THE death took place recently at the age of 59 years of Mr. A. G. Salamon, a past-president of the Institute of Chemistry. Mr. Salamon was well known as a consulting analytical chemist.

MR. T. B. GILLIES, metallurgical chemist, of Bushey Hall Road, Watford, has died in consequence of burns received while conducting experiments at the premises of Messrs. Hobson, James, & Gilby, metal manufacturers, Birmingham.

THE death took place recently of Mr. Walter Hamer, chairman of the Vulcan Motor & Engineering Company, Limited, of Southport, at the age of 72 years. He was formerly a director of Howard & Bullough, Limited, of Accrington.

THE death is announced, at the age of 36 years, of Mr. W. Vaughan, son of Mr. W. S. Vaughan, of the firm of Messrs. Vaughan and Dymond, engineers and iron merchants, Newcastle, and chairman of the Blyth Shipbuilding Company, Limited.

THE death is announced of Mr. T. J. Hill, Cawney Hill House, Dudley. He was a director of the Stourbridge Glazed Brick Company, Limited, of Dudley and Pensnett, and the Dudley Foundry Company, Limited. He was 56 years of age.

LIEUT. J. D. THOMAS, R.A.F., who was killed in a flying accident in Hampshire, was a son of Mr. J. J. Thomas, formerly of Messrs. Losh, Wilson, & Bell's Ironworks, Walker, Newcastle-on-Tyne, and latterly connected with iron and steel works in America.

THE death is reported, at the age of 60 years, of Mr. Robert Wright, of Stockton. The deceased gentleman went to Stockton many years ago, commencing business as a scrap-iron merchant, etc., and, by dint of industry, he built up an extensive connection.

MAJOR A. G. PARSONS, R.F.A., who was killed in action on April 26, was the only son of the Hon. Sir Charles A. Parsons. He received his first commission in 1906, and after serving three years retired to enter the engineering profession. He was a director of C. A. Parsons & Company, Limited, Heaton Works.

THE death took place last month of Mr. Richard Laithwaite, chief engineer of the Wigan Coal and Iron Company, Limited, at his residence De Trafford House, Ince, Wigan. The deceased, who was 57 years old, was a native of the Wigan district, and he began his career as an engineering apprentice with the Wigan Coal and Iron Company, Limited, having been with the firm throughout his career, first as apprentice, then as assistant, and later as chief engineer.

THE death has taken place at Frimley Hall, Camberley, Surrey, of Mr. J. F. Wright. For many years he was head of the firm of J. & E. Wright, gas stove manufacturers, Birmingham, which business was amalgamated with the Eagle Range, and became known as John Wright & Eagle Range, Limited. Subsequently Mr. Wright retired from the business, and devoted his attention to the Sutherland Meter Company, but twelve months ago he retired from that concern on account of ill-health. He was a director also of C. & W. Walker, Limited, and the Lilleshall Company, Limited.

WHILE attending a committee meeting at the Ministry of Munitions, last month, Sir Alexander Pedler, C.I.E., F.R.S., died suddenly. Born in 1849, son of the late Mr. G. S. Pedler, of Dulwich, Sir Alexander was educated at the City of London School and the Royal College of Science. Appointed to the Bengal Education Department in 1873, he became Professor of Chemistry, and afterwards Principal of Presidency College and Director of Public Instruction for Bengal. In 1904 he became vice-chancellor of Calcutta University. Since the outbreak of war he has been serving in the Munitions Department in connection with scientific research.

New Tin Order.

By an order dated April 26, 1918, the Minister of Munitions has taken entire control of trading in tin. In future no person may purchase, sell, or—except for the purpose of carrying out a contract in writing existing prior to the date mentioned—enter into any transaction or negotiation in relation to the sale or purchase of tin situated either inside or outside the United Kingdom, except under a Ministry licence. Likewise, no tin may be used, except under licence, for the purpose of any manufacture or work except for the purpose of a contract or order for the time being in existence certified to be within class "A" in the order of the Minister of Munitions as to priority dated March 8, 1917.

In the first seven days of each month commencing with May, 1918, all persons are to send in to the Director of Tin Supplies, 1, Metal Exchange Buildings, Whittington Avenue, E.C.3, monthly returns of:—

(a) All tin held by them in stock or otherwise under their control on the last day of the preceding month, specifying the quality.

(b) All tin purchased or sold by them for future delivery and not yet delivered on such last day, specifying the names of the sellers to or purchasers from them, and the quantity and quality, and time and place of delivery in each case, and the position of the tin at the date of the return.

(c) All tin delivered to them during the preceding month, and from whom purchased.

(d) All contracts or orders existing on the last day of or entered into during the preceding month requiring for their execution the use of tin, specifying the purposes thereof and the quality of the tin to be used.

No return is, however, required where the total stock of tin in hand and on order has not at any time during the preceding month exceeded 5-cwt. For the purpose of this order the expression "Tin" means tin of all qualities, and includes sheet and rolled tin, tinfoil, scrap tin, tin ores, and concentrates, and tin residues.

All applications for licences should be made to the Director of Tin Supplies, Metal Exchange Buildings, Whittington Avenue, London, E.C. 3, and marked "Tin Licence." Every applicant for a licence must state the amount and quality of metal required by him per month, and the use to which it will be put.

Experimental Construction of Aero Engines.

From May 15 no person may, without a licence from the Minister of Munitions, commence or proceed with the experimental construction of any aero-engine: provided that where a first application for a licence has been made and is pending for the carrying on of any experimental construction which had been commenced before May 15, such construction may be continued until the licence has been refused.

For the purpose of the order issued, on May 10 by the Minister of Munitions, the term experimental construction means any construction which is not under or for the direct purpose of fulfilling a Government contract, and includes the preparation of any working drawings but not the preparation of general arrangement drawings.

Every person desirous of obtaining a licence to commence or carry on such experimental construction must apply to the Director-General of Aircraft Production, Kingsway, W.C.2, and should give full particulars of the construction for which the licence is required. The order is cited as the Aero-Engine (Experimental Construction) Order, 1918.

Personal.

SIR HENRY NORMAN, BART., M.P., has resigned his position on the Air Council.

MR. R. A. BROWN has been elected Master of the Armourers' and Brasiers' Company.

MR. P. W. FAWCETT, of Sheffield, has been elected a director of the Parkgate Iron & Steel Company, Limited.

THE late Mr. W. S. Accles, European manager of the Niles-Bement-Pond Company, left estate of the value of £16,335 gross.

THE RIGHT HONOURABLE VISCOUNT MIDLETON, K.T., has recently joined the Board of the Barrow Hematite Steel Company, Limited.

MR. C. E. FURNESS, a director of Furness, Withy & Company, Limited, has been dangerously wounded in the head by shrapnel.

THE late Mr. C. Davis, metal broker, of Rood Lane, E.C., left estate of the gross value of £16,866, of which £16,765 is net personalty.

CAPT. S. G. HAGUE (awarded the Military Cross) was at the outbreak of war resident in Newcastle as the Carron Company's foundry agent.

MR. JOHN DAVISON has resigned his position as commercial manager of the Lanarkshire Steel Company, Limited, to take up an appointment in London.

MR. C. H. WORDINGHAM, Director of Electrical Engineering to the Admiralty, has been re-elected president of the Institution of Electrical Engineers.

SEC.-LIEUT. Q. D. TURNER, who is a prisoner of war in Germany, is the only son of the late Mr. J. Turner, of the Ailsa Shipbuilding Company, Limited, Troon.

THE late Mr. Greville Jones, of Middlesbrough, formerly manager of the Clarence Blastfurnaces and Steel Works, left estate of the gross value of £16,303.

MR. DOUGLAS VICKERS, J.P., of Vickers, Limited, is the prospective candidate of the Hallam (Sheffield) Conservative Association for the next general election.

MR. H. BROADBENT, ironfounder, Heckmondwike, has been seriously injured by, it is presumed, falling between the train and the platform at Heckmondwike Station.

THE late Mr. S. A. Steel, who was interested in Steel, Peech & Tozer, Limited, Sheffield, and was the third son of the late Mr. Henry Steel, of Sheffield, left £89,500.

MR. GEORGE KRYN, formerly managing director of Kryn & Lahy Metal Works, Limited, Halton House, 20-23, Holborn, London, E.C.1, is not now connected with the Company.

PTE. A. ONIONS, the son of Mr. Z. Webb Onions, of the Wolverhampton Steel & Iron Company, Limited, who was wounded on April 7 in France, has been awarded the D.C.M.

MR. W. J. COCKS, hitherto with Messrs. Vivian & Sons, has been appointed secretary of the English Crown Spelter Company, Limited, and also of the Spelter Manufacturers' Association.

MR. M. MCGRATH, works foreman to the Birchills Furnaces, Limited, Walsall, has been the recipient of a presentation from the officials and workmen on being awarded the Order of the British Empire.

MR. W. J. BROOKE, of the Shelton Iron, Steel & Coal Company, Limited, has been appointed steel works manager to the Redbourn Hill Iron & Coal Company, Limited, a position rendered vacant by the resignation of Mr. W. H. Wass.

SIR JOHN BRUNNER, BART., has resigned the chairmanship of the board of Brunner, Mond & Company, Limited, after having occupied the position since 1891. The directors have elected Mr. Roscoe Brunner in his stead. Sir John Brunner remains on the board.

AFTER 14 years' service with the Cargo Fleet Iron Company, Limited, Middlesbrough, Mr. H. S. Peacock is leaving to take up the position of commercial manager of the Lanarkshire Steel Company, Limited. He has been the recipient of a presentation from his colleagues at Cargo Fleet.

CAPT. W. HEALEY GRAHAM, R.E., of Barry, has been awarded the Military Cross. He was, prior to taking up active service, manager to the Junction Dry Dock & Engineering Company, Cardiff and Barry, and of the Tubal Cain Engineering Works, Cardiff, and also a director of both companies.

MR. T. SELBY ELLIOTT has been the recipient of a presentation from the officials and staff of Sir W. G. Armstrong, Whitworth & Company, Limited, Walker shipyard, on the occasion of his leaving the firm to take up the secretaryship of the newly-formed Shipbuilding, Engineering and Steel Commercial Staffs' Association.

MR. R. COOPER, secretary of the Wholesale Hardware Association, Limited, has been appointed Honorary Hardware Adviser to the Department of Import Restrictions, Board of Trade, and secretary to the Advisory Committee on Hardware appointed to assist the Department in connection with the control of hardware imports.

SIR WILLIAM WEIR, who was recently appointed to be Secretary of State for the Air Forces in succession to Lord Rothermere, has taken a prominent part in the work of the Air Ministry ever since its establishment. At first he was Director of Munitions for Scotland, and later became head of the Supply Department at the Ministry of Munitions. He has for some time been Director-General of Aircraft Production.

THE MINISTER OF MUNITIONS has appointed Sir Arthur Duckham, K.C.B., to superintend, as member of Munitions Council, the duties of aircraft production, in succession to Sir William Weir, on the latter's appointment as Secretary of State and President of the Air Council. Sir Arthur Duckham, who received the K.C.B. last year, has been chairman of the Advisory Committee of the Ministry of Munitions. He served his apprenticeship in engineering workshops under Sir George Livesay, and specialised in furnace work, coal carbonisation, and engineering connected with chemical developments, in regard to which and kindred subjects he has taken out numerous patents.

Applications for Patents.

Aitken, T. W. Crucible furnaces for melting metals. 7,474. May 3.

Ashcroft, E. A. Manufacture of the metal magnesium and/or alloys of magnesium with other metals by electrolysis. 7,705. May 8.

Ashcroft, E. A. Process for treatment of complex or refractory sulphide ores or products, and recovery of the non-ferrous metals with or without by-products. 7,706. May 8.

Atkinson, J. S., and Stein & Atkinson. Charging furnaces. 7,294. May 1.

Aubert, A. M. Furnaces. 7,473. May 3. (France, May 12, '17.)

Blake, Inc., C. C. Casting patterns, and manufacture thereof. 7,306. May 1

Burnett, J. M., and Jones, F. P. Case-hardening materials. 7,556. May 6.

Burr, E. G. Admixture of metals or substances for alloying. 7,311. May 1.

Crocker, C. and C. W. Manufacture of zinc. 7,505. May 4.

Harvey, E. W., and Harvey Gas Furnace Company, E. W. Regenerative or recuperative furnace installations. 7,529. May 4.

Industrial Inventions, Limited. Production of malleable iron castings. 7,049. April 26.

Mordey, W. M. Heat treatment of iron and steel and alloys thereof. 7,752. May 8.

Procter, H. C. Aluminium solder. 7,128. April 27.

South Durham Steel & Iron Company. Gas or air ports for regenerative furnaces. 6,376. April 16.

South Durham Steel & Iron Company. Regenerative furnace reversing valves. 6,378. April 16.

Stabilimenti Biak—Ing. A. Pouchain. Process for melting metals. 7,642. May 7. (Italy, May 7, '17.)

Stobie, V., and Taylor, T. W. Guideway for foundry ladles. 6,890. April 24.

Sumpter, C. L., and Vickers, Limited. Surface-hardening steel plates, etc., and iron and malleable iron castings. 6,537. April 17

Unsworth, P. and T. Lock scotch for tipping blast-furnace slag ladles. 7,419. May 3.

Wright & Eagle Range, Limited, J., and Yates, H. J. Tilting crucible furnaces. 7,467. May 3.

Trade Talk.

MESSRS. J. H. GRANT & COMPANY, tool makers, have removed to Oak Road, North Heath, Erith, Kent.

THE INTERNATIONAL NICKEL COMPANY OF CANADA and the Canada Copper Company are to amalgamate.

THE export of copper, brass, bronze, nickel silver, and metals containing copper, both manufactured and scrap, has been prohibited from Norway.

MESSRS. H. PEERS AND J. GRIMSHAW, engineers, High Street, Bolton, trading under the style of Grimshaw & Peers, have dissolved partnership.

THE offices and warehouse of Hays, Hunter & Standen, Limited, engineers, 110, Cannon Street, E.C.4, have been removed to 71, Southwark Street, S.E.1.

MESSRS. NORTON, OWEN & COMPANY, iron, steel, and metal merchants, 4, Bishopsgate, London, E.C.2, have removed to 6, Great Winchester Street, London, E.C.2.

THE Committee on Work of National Importance have removed from Carlton House, Regent Street, S.W.1, to Fitzalan House, Arundel Street, Strand, W.C.2.

THE Federation of British Industries, by a resolution of the executive council, has now given its support to the Decimal Coinage Bill, which is before the House of Lords.

THE wholesale department and warehouse of Drake & Gorham, Limited, 1, Felix Street, Westminster Bridge Road, S.E.1, have been transferred to Felix House, 67, Long Acre, W.C.2.

MESSRS. A. C. STUART & M. LEACH, small tool makers and merchants, 32, Queen Victoria Street, London, E.C.4, trading under the style of Leach, Stuart & Company, have dissolved partnership.

THE members of the West of Scotland Iron and Steel Institute have refused to sanction the suggested change in the title of the Institute to "The Iron, Steel and Metallurgical Institute of Scotland."

RICHARD LLOYD & COMPANY, LIMITED, Galton Works, Steelhouse Lane, Birmingham, have taken over the business of Thomas Lockhart & Company, engineers' tool dealers, Steelhouse Lane, Birmingham.

IT has been arranged by mutual agreement that the work hitherto done in the London district by the Metropolitan Munitions Committee shall be transferred to the Ministry of Munitions as from July 1.

THE partnership heretofore subsisting between Messrs. O. I. Philipp and R. P. Lion, carrying on business as metal merchants, at 2, Broad Street Place, London, E.C., under the style of Philipp & Lion, has been dissolved.

THE PREMIER COOLER & ENGINEERING COMPANY, LIMITED, Broadway Court, Broadway, Westminster, London, S.W.1, are moving their head offices to the Station Works, Shalford, near Guildford, Surrey, on May 22.

AT the annual meeting of the Staffordshire Iron and Steel Institute, on April 26, Mr. George Carrington (Bilston) was elected president, and Mr. Frank Somers (Hales Owen) was elected vice-president.

THE MINISTER OF MUNITIONS has made an Order dated May 7 providing that as from May 15, and until further notice, no rifle, pistol, revolver, or shot gun, or parts of them, may be manufactured or repaired except under licence.

THE petition of the Farnley Iron Company, Limited, for the sanction of the Court to certain special resolutions passed by the company for the purpose of extending their power in relation to the manufacture of steel, has been assented to.

THE partnership heretofore subsisting between Messrs. E. Walton and W. H. Morris, carrying on business as general engineers and tool makers, at 216 and 218, Icknield Port Road, Birmingham, under the style of Walton & Morris, has been dissolved.

A SNYDER furnace, of 1,250-lb. capacity, together with the auxiliary electrical equipment, has been shipped to Burn & Company, Calcutta, India, who are one of the largest structural steel and foundry firms in that country.

THE PONT-A-MUSSON BLAST FURNACE COMPANY, one of the largest French firms of cast-iron pipe founders, have opened an office at 317, High Holborn. They have hitherto been represented in this country by Sophus Berendsen (London), Limited.

A NEW limited liability company has been established at Leith for the purpose of carrying on the business of shipbuilders, repairers, and engineers under the style of Henry Robb, Limited. Mr. Henry Robb was until recently shipyard manager with Ramage & Ferguson, Limited.

MESSRS. W. L. DAVIES & A. SOAMES, Faraday House, 66, Southampton Row, London, W.C.1, have granted a licence to the Equipment & Engineering Company, 2 and 3, Norfolk Street, Strand, London, W.C.2, for the use of the "Daysohms" magnetic clutch for arc welding machines.

Our Parliamentary correspondent states that on the third reading of the Finance Bill after the Whitsuntide recess, Mr. G. Terrell, M.P., at the instance of the Federation of British Industries, will again call attention to the question of income-tax allowances for depreciation of plant and machinery.

MESSRS. J. HEATH, F. H. JACKSON, L. H. JACKSON, & D. DOWSE, as executors of the late F. T. Jackson, K. Hathaway, and W. Birkett, iron, aluminium, and brass founders, Read Street, Coventry, trading under the style of the Coventry Motor Foundry Company, have dissolved partnership, so far as regards Mr. J. Heath.

THE British Science Guild is organising a comprehensive exhibition of products and appliances of scientific and industrial interest, which, prior to the war, were obtained chiefly from enemy countries, but are now produced in the United Kingdom. The exhibition will be held at King's College, London, for four weeks during the coming summer.

THE extensions to the works of the Parkgate Iron & Steel Company, Limited, are making good progress, and the new blast furnace will be ready for work in a few weeks' time. The directors have acquired a further area of freehold land, consisting of about 69 acres, adjoining the Midland Railway, making about 213 acres for future use.

WORK has been started on the erection of a ferro-silicon plant at Beaupre, Que., for the Laurention Power Company, Seven Falls, Que., to cost £60,000. It is expected that the plant will be completed and in operation within three months, the company having a large contract with the Imperial Munitions Board. The plant will have a capacity of from 12 to 15 tons per day.

THE rail-welding business of the Tudor Accumulator Company, Limited, has been acquired by the managing director of the company, Mr. E. Jacob, who will continue the business on his own account as the Rail-Welding Company at 119, Victoria Street, Westminster, S.W.1. Mr. Jacob will, however, continue as managing director of the Tudor Accumulator Company.

ACCORDING to the Timber Order, 1918, dated April 25, no person in the United Kingdom may "buy, sell, or receive, or enter into any transaction or negotiation in relation to the sale, purchase, or transport, of any timber grown outside the United Kingdom which is not actually in stock in the United Kingdom at the date of this Order" except under a permit granted by the Controller of Timber Supplies.

THE THAMES SHIPBUILDING YARD, belonging to Messrs. A. W. Robertson & Company, has just changed hands, owing to Mr. Robertson retiring from business. The freehold property, together with the business as a going concern, has been sold to Blane & Company, Limited, of London and Cardiff. The business will in future be carried on under the style of the Lea Shipbuilding & Repairing Company, Limited.

THE COMPTOIR NATIONAL POUR LA REPRISE DE L'ACTIVITE ECONOMIQUE EN BELGIQUE Société Coopérative has been formed, with the co-operation and

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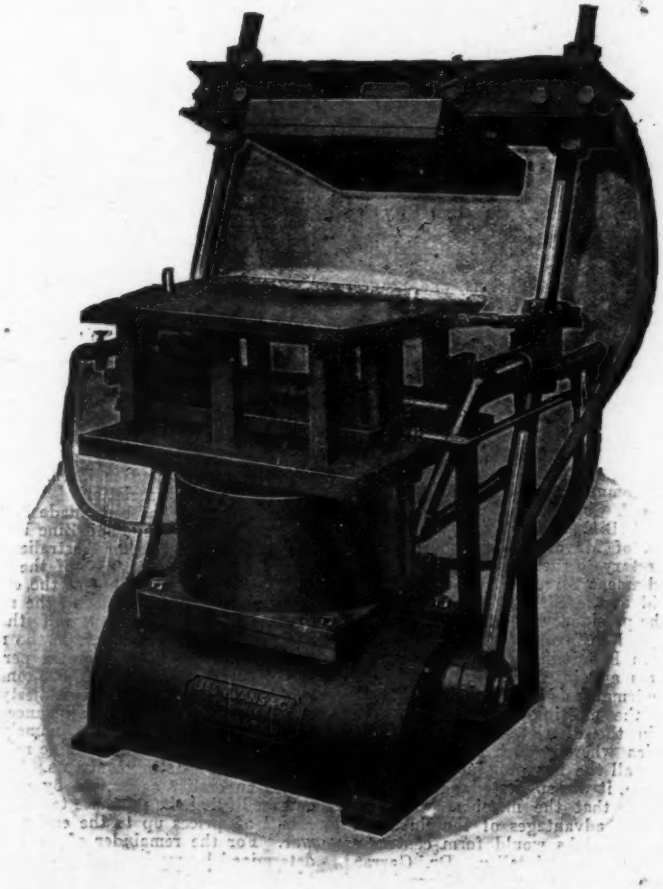

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under the control of the Belgian State, having for its object the economical reconstruction of Belgium. This organisation, which proposes to help industry and trade by assisting in the purchase of tools and all necessary raw materials, has its offices at 110, Cannon Street, London, E.C.4.

THE final meeting of the 1917-18 session of the Liverpool Engineering Society was held on April 24, when the president, council, and honorary officers for the ensuing session were elected. Mr. R. Croston read a paper entitled "Photo Micrographic Examination of Metals." Mr. H. Dickinson, the retiring president, occupied the chair during the earlier proceedings, and was later succeeded in the chair by the newly-elected president, Professor J. Wemyss Anderson.

RUSTLESS IRON (COWPER-COLES PROCESS), LIMITED, which has recently been formed, has acquired works at Shepperton with a railway siding into the premises. The company will specialise in rustless fittings of all descriptions, especially for seaplanes and aeroplanes, also ships and railway fittings. The company has acquired some improvements in Sherardising from Mr. Cowper Coles, also a new process called "Doxidising," which is specially suitable for steel fittings exposed to salt water, as the zinc coating itself is protected from corrosion.

As briefly announced elsewhere, the London Iron and Steel Exchange was registered on April 30 as a private company, with a capital of £2,000 in £1 shares, to provide a building or rooms for an iron, steel, and allied trades exchange in the City of London. The other objects of the company are to adjust controversies between members, to establish just and equitable principles in the trades mentioned, to maintain uniformity in rules, regulations, and usages, to adopt standards of classification, and generally to promote the interests of trades. The registered office is at 113, Queen Victoria Street, E.C.

THE MINISTER OF MUNITIONS has appointed a Committee with the following terms of reference:—"To advise the Minister upon the general principles to be adopted in carrying out the Welfare and Health Work of the Ministry, and to report to the Minister in all matters connected with the same which may be referred to them by him from time to time." The constitution of the Committee includes: Mr. W. H. Allen, of Allen, Sons & Company, Limited, Bedford; Mr. A. F. Butler, O.B.E., Ministry of Munitions; and Mr. S. Mavor, of Mavor & Coulson, Limited, Glasgow. The secretary to the Committee is Mr. R. H. Croake, 53, Parliament Street, S.W.1.

AT a meeting held at the Birmingham Chamber of Commerce, under the presidency of Dr. C. C. Garrard, a resolution was passed in favour of the formation of an Engineers' Club in Birmingham for the Midlands, and a committee was appointed to carry the scheme into effect. The chairman said it was hoped that the club would become the meeting-place of the various technical societies in the district. The scheme was part of a larger idea whereby such engineers' clubs would be founded in all the large engineering centres in the country. These, it was suggested, should eventually be federated, so that the members would not only have the practical advantages of the clubhouses in their travels, but the clubs would form centres of engineering activities in each locality. Dr. Garrard and Mr. J. Fearn were respectively elected provisional chairman and hon. secretary.

THE INSTITUTION OF GAS ENGINEERS and the Society of British Gas Industries propose to again contribute £150 each for the purposes of the refractory materials research; and the Privy Council Committee for Scientific and Industrial Research will, it is hoped, make a grant of £330 for 1918. Although the whole of last year's grant has not been expended, it is hoped that an additional worker may be secured, in which case the whole of the above amounts will be required. As a result of the conference on the Organisation of Refractory Materials Research much correspondence has taken place on a proposed Association for Refractories Research. The Joint Refractory Materials Committee have made certain suggestions on the matter; and it is hoped that a satisfactory arrangement will be come to which will secure co-ordination in the various researches now in progress, or which in future may be instituted.

In the House of Lords last months, VISCOUNT CHILSTON moved the second reading of the British Aluminium Company (Lochabar Water Power) Bill, for which he asked approval on the ground that it would foster the key industry of aluminium production. LORD BALFOUR OF BURLEIGH opposed the Bill and moved that it be read that day six months. The EARL OF KINTORE, Chairman of Committee, reported that the Board of Trade and the Ministry of Munitions favoured the Bill being proceeded with. He, however, thought it might be left over until the end of the war. The works would cost about one and a-half million. LORD HYLTON, for the Board of Trade, urged that the Bill should be read a second time and sent to a committee for inquiry. The MARQUIS OF CREWE and the MARQUIS OF LANSDOWNE opposed the Bill. VISCOUNT CHILSTON intimated that in view of the expressions of opinion by the House he would withdraw the Bill. The motion for the second reading was, by leave, withdrawn.

THE BIRMINGHAM BRASS MASTERS' ASSOCIATION have been giving consideration to the reconstruction problems which will arise on the cessation of hostilities, and they have arrived at the conclusion that if British traders are adequately to meet German efforts in neutral markets much of the old method of trade has to go, and in its place there will have to be set up an intensified system of production. Brass masters whose works can be easily adapted to the production of certain goods will be asked to specialise in those things for the whole of the trade. The Government have issued certificates for the use of non-ferrous metals for export trade to the Colonies and British Dependencies, exclusive of Canada, the exclusion of Canada being based on the promise of America to supply Canadian needs for copper without it being sent into and out of the present submarine danger zone. A portion of the metal controlled for a part of the country will be allocated by the Brass Masters' Association for essential repairs and maintenance, the permits being granted by the Association.

AN agreement has been made between the President of the Board of Trade and Zinc Producers' Association Proprietary, Limited, of Australia, for the purchase by His Majesty's Government of the stocks of Australian zinc concentrates existing at the end of last year, less reserves, and also, subject to the reasonable protection of Australian requirements, of the production, from the beginning of this year, to the maximum extent of 250,000 tons per annum for the period of the war and one year thereafter, and 300,000 tons per annum for the subsequent nine years. His Majesty's Government also secures an option over the balance of production subject to certain reservations, namely, provision for the requirements of Australian zinc refining works and the fulfilment of existing contracts. The agreement, which varies an earlier agreement by enlarging the quantity and modifying the purchase terms, provides for a "flat rate" of prices up to the end of five years after the war. For the remainder of the period prices will be determined by market conditions with the "flat rate" of the earlier period as a minimum.

The iron alloys which have answered in the manufacture of acids, partly replacing stoneware, are ferro-chrome and silicon-iron, says the "Chemical Trade Journal." Ferro-chrome is not, or but little, attacked by sulphuric and nitric acids, weak or strong, nor by glacial acetic acid, but is readily attacked by hydrochloric acid. The chief Si-Fe alloys are "tantiron," "duriron," and "ironac." These alloys resist strong and weak sulphuric and nitric acids. The composition of tantiron is given by Mr. W. C. Carnell, in a paper to the American Institution of Chemical Engineers, Cleveland, as:—Si, 14 to 15; Mn, 2 to 2.75; C (graphite), 0.75 to 1.25; S, 0.05 to 0.15; P, 0.05 to

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0.1 per cent.; density, 6.8; melting point, 2,550 deg. Fah.; tensile strength, 6 to 7 tons per sq. in. Tantiron will not stand high internal pressures unless strengthened. Duriron consists of Si, 14 to 14.5; C (total), 0.2 to 0.6.; Mn, 0.25 to 0.35; P, 0.16 to 0.2; S, under 0.05 per cent.; density, 7.0; melting point, 2,500 to 2,550 deg. Fah.; compression strength, 70,000 ibs. per sq. in.; tensile strength, 25 per cent. less than cast iron.

At the concluding meeting of the session of the Birmingham Metallurgical Society, held at the Chamber of Commerce, on Thursday, May 9, Professor Turner (president) in the chair, a paper was read by Mr. W. J. Foster on "The Blast Furnace and its Resources." The reading of the paper was preceded by the annual meeting of the Society. The council, in its report of the thirteenth session of the Society, congratulated the members upon the success which had been obtained from the reorganisation in December last. During the session 198 new members and 28 student members had been elected, bringing the total to 356, an increase of 226. The treasurer's report showed a balance in hand of £47. Mr. Isaac Lester had been elected by the council president for the ensuing year, and Mr. T. Vickers has been re-elected hon, secretary and Mr. H. Rogers as hon. treasurer. The report was adopted, and a resolution was passed authorising the council to arrange for a scheme of five-guinea prizes to encourage the study of metallurgy. Mr. Foster promised to finance for five years a similar scheme to be administered by the Society.

A Proclamation has been issued, dated May 14, amending the list of prohibited exports as follows:- Headings deleted: (A), Boilers; (B), ferro-nickel; (B), nickel; alloys of nickel, and nickel ore; (C), nickel manufactures, not otherwise prohibited (except nickel-plated goods). Headings added: (A), Boilers, including portable boilers, and their component parts; (A), cement for building and engineering purposes; (A), coppers, and their component parts; drums, iron or steel, other than such drums as contain goods to be shipped for exportation, and are allowed by the Commissioners of Customs and Excise to be shipped as the containers of such goods; (A), ingot moulds manufactured of hematite iron; (A), mattresses, wire, fitted on wooden frames; (A), nickel, its ores, alloys, and manufactures (except nickel-plated goods, not otherwise prohibited); (A), piping, sheet iron or steel, for stoves or for ranges, and parts thereof; (A), ranges, cooking, and their component parts; (A), stoves, heating, capable of consuming coal, coke, or other solid fuel, and their compoent parts; (A), choppers, cleavers, road-scrapers, and wedges (wood-splitting).

According to an article in the annual report of the Ontario Bureau of Mines for 1917, two firms in Ontario have undertaken the manufacture of ferro-molybdenum during the past year—the International Molybdenum Company and the Tivani Electric Steel Company—and both companies are now steady producers. The International Molybdenum Company made an experimental run on a laboratory scale at their Orillia plant in May 8, 1916, and in the following September began work on a commercial scale. The furnace is a single-arc tapping type. The capacity of the original furnace was about 125 lbs. In the earlier runs pure molybdic acid was mixed with iron, flux and coke. Later runs were made with roasted concentrates, which in some cases still carried sulphur. The resulting ferro-molybdenum in both cases was practically free from sulphur, as this is volatilised in the intense heat of the arc, or is in part taken up by the slag. The Tivani Electric Steel Company, of Belleville, have also been making ferro-molybdenum since September, 1916. The furnace used is a triple-arc Evans-Stansfield furnace. It is a large furnace, but easily manipulated. A smaller two-arc tapping furnace was used for an earlier run. This company has been shipping ferro-molybdenum steadily during the autumn. The charge that was being treated at the time of the writer's visit was composed of molybdenite, with additions of iron and flux. The sulphur in the molybdenite was practically all taken up by the slag, or converted into sulphur dioxide, so that the resulting ferro-molybdenum was practically free from sulphur. As a result of this, it is recommended that the grade of molybdenite concentrates should not exceed 70 per cent.

Mr. Douglas Vickers, speaking at Sheffield on April 25, said that the directors of Vickers, Limited, had given a great deal of attention recently to projects for the future, and had discussed the most varied plans for utilising for peace purposes as much as possible of their war plant. As he had said repeatedly before, a very great portion of it would be quite unuseable, and the best suggestion that he could make was that this class of plant (including rifling machines and many of their shell machines) should be taken up and stored in one of their big buildings ready for use in case Germany attacked us again. At one factory, for instance, where they had a large number of machines for the manufacture mainly of automatic guns, there would be a somewhat larger proportion of what he might call general service machines than in their other works, and they proposed to put some 1,700 machines on to the manufacture of sewing machines, which would, they hoped, secure them, within a few months of the end of the war, a very considerable output. They were already manufacturing at another place sewing machines for sale in order to test the market. At another of their works in the South they proposed to manufacture on a large scale certain semi-electrical devices for motor-cars that they thought would have a large application, and also another speed-controlling apparatus. At another place which had very good wharfage they were proposing to put down works to manufacture various wooden articles. A good deal of this work would be new. They proposed to utilise for that purpose a quantity of the machinery that they had got for war purposes. At Barrow they were arranging for building a much greater proportion than before of mercantile ships, and were also making plans for developing their manufacture of heavy oil engines, and for the manufacture of land boilers and large gas engines. They expected much from both these developments in view of the extensive electrical projects that they thought were certain to be realised after the war, when the period of reconstruction throughout the country came. They were already interested in electrical work, of course, at Sheffield. Although they did not propose to extend their Sheffield works much, they proposed to continue them and to specialise in them. They had rather wide electrical schemes before, and they had proposed to put up works on a fairly large scale, probably outside Sheffield. But they had recently put before them an offer, which they accepted, to be associated with the Metropolitan Carriage, Wagon and Finance Company in the control of the British Westinghouse Company. They thought this presented much better prospects than building new works, which would have taken a very long time to get into working order. They did not propose to discontinue manufacturing electrical material in Sheffield—they would continue on much the same lines as before, but probably specialising to a greater extent.

Power-Driven Machine Tools.

The announcement is made that power-driven machine tools or woodworking machines and treadle lathes for woodworking or metal (3in. centres and over) come under Regulation 30 A of the "Defence of the Realm Regulations."

Intending purchasers must make application for permission to purchase the machines they require to the executive officer of the Area Clearing House Board in their district.

Firms (including auctioneers) must obtain permission to sell machines from the Controller of Machine Tools, Charing Cross Buildings, Embankment, W.C.2.

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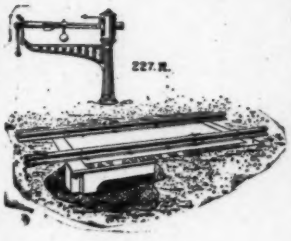

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Owen Davies Engineering Company, Limited. — Capital £5,000 in 5s. shares.

Files (Sheffield), Limited.—Capital £500 in £1 shares. Registered office: 7, Bank Street, Sheffield.

Edward Kempster & Sons, Limited.—Capital £10,000 in £1 shares; to carry on the business of engineers.

Marine Governors, Limited.—Capital £2,000 in £1 shares. Registered office :—60, Watling Street, E.C.

Groome & Tattersall, Limited.—Capital £12,000 in £1 shares, to carry on the business of milling engineers.

J. S. Zenelet, Limited.—Capital £3,000 in £1 shares, to carry on business as mechanical and electrical engineers, etc.

General Aeronautical Company, Limited.—Capital £30,000 in £1 shares. Registered office: 30, Regent Street, S.W.

Gillespie Gauge & Tool Company, Limited.—Capital £5,000 in £1 shares. Registered office: 50, Wellington Street, Glasgow.

Charles Kenyon & Son, Limited.—Capital £15,000 in £1 shares, to carry on the business of steel and metal roller manufacturers.

Metropolitan File Manufacture, Limited. — Capital £1,000 in £1 shares. Registered office :—2-6, Queen's Road, Teddington.

Metallurgical Plant Construction Company, Limited. —Capital £8,000 in £1 shares. Registered office: 47, Victoria Street, S.W.1.

London Iron & Steel Exchange, Limited. — Capital £2,000 in £1 shares. Registered office: 113, Queen Victoria Street, London, E.C.

Eastern General Welding & Brazing Works, Limited. —Capital £3,000 in £1 shares. Registered office: 75A, East Road, Portway, West Ham, E.13.

J. E. & S. Spencer, Limited.—Capital £10,000 in £1 shares, to carry on the business of iron merchants, etc. Registered office: 16, Dowgate Hill, E.C.

M. Bonser & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of brass founders, etc. Registered office: Orange Street, Sheffield.

Harvey & Mutlow, Limited.—Capital £100 in £1 shares, to carry on the business of ironfounders, etc. Registered office: 10, Union Passage, Birmingham.

R. L. Dubois & Company, Limited.—Capital £2,000 in £1 shares, to carry on the business of engineers. Registered offices: 5, Khartoum Parade, Ilford Lane, Essex.

Parrot & Janes, Limited. — Capital £4,000 in £1 shares, to take over the business, of motor and general engineers, etc., carried on at the Leighton Engineering Works, North Street, Leighton Buzzard, Beds., as Parrott & Janes.

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Will you please quote us your best price for four more like it,
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(Signed) W. B. LAKE, Director.

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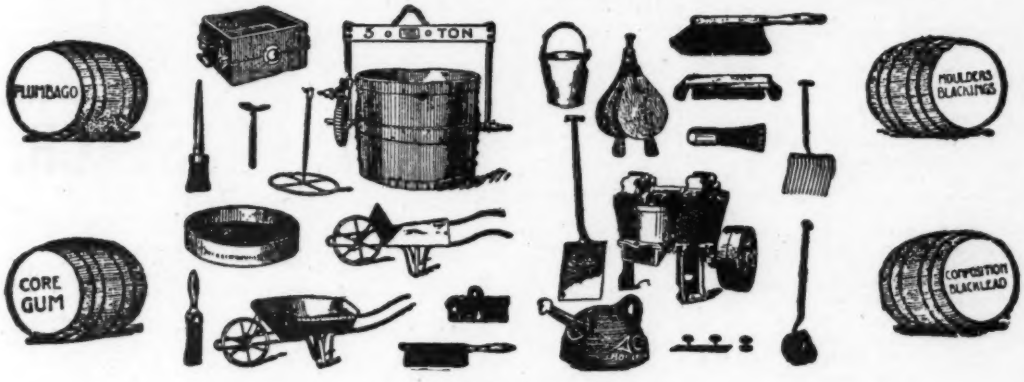

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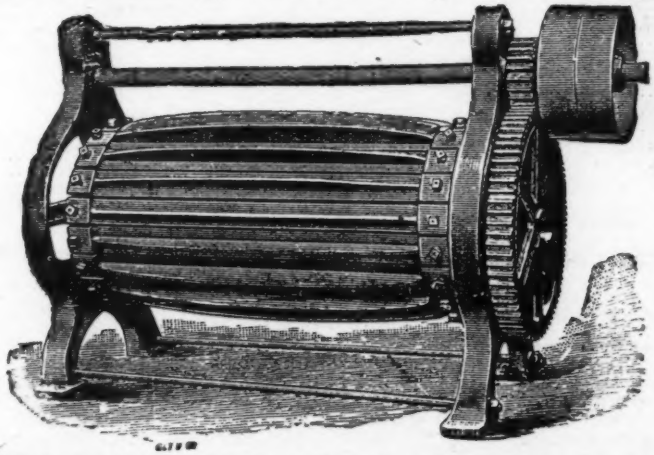

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Special under 0.03 P. & S... ..	6	15	6
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East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
" " 0.02 "	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3...	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
" " 0.02 "	7	0	0
HEMATITE—MALLEABLE—			
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Refined Cupola Cast	8	0	0
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Small Pig-Iron, all grades ..	7	10	0
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Medium Pig-Iron, all other qualities	6	17	6
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Lincolnshire, basic or foundry ..	4	17	6
Cleveland, No. 1	4	19	0
" other grades	4	15	0
" basic	5	0	0
Northamptonshire, forge	4	7	6
" fdy numbers	89/0		94/0
" basic	4	17	6
Derbyshire, forge	4	10	0
" foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
" " foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
" " foundry	4	17	6
" " basic	4	17	6
South Staffordshire—			
Part mine forge	5	0	0
" foundry	5	2	6
Common Staffordshire ..	4	15	0
All mine forge	5	15	0
" foundry	6	0	0
Warm air forge	7	5	0
" foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works.

Mers. Com. 1¼%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 3s. 8d.

Finished bars, 18% Tung. 4s. 5d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	8d.
Bar Ends	9d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless..	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	26	10	0
export ..	—		
"	—		

* F.o.b. Liverpool.

Non-Ferrous Metals.

	£	s.	d.	£	s.	d.
Copper.						
Standard, Cash	110	0	0	110	10	0
Three months	110	0	0	110	10	0
Electrolytic ..	125	0	0	121	0	0
Tough	123	0	0	119	0	0
Best selected ..	123	0	0	119	0	0
Tin.						
Standard, Cash	349	0	0	350	0	0
" Three months	349	0	0	350	0	0
English Ingots	354	0	0	—		
Bars	355	0	0	—		
Refined	—			—		
Spelter.						
American	54	0	0	50	0	0
Specials..	—			—		
Hard	45	0	0	46	0	0
British	56	10	0	57	0	0
Lead.						
Soft Foreign (net)	29	10	0	28	10	0
English	—			Nom.		
Antimony.						
Regulus	—			85	0	0
Aluminium.						
Virgin Metal 98/99% per ton	—			—		

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. o V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
" Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. £50 above price of best selected copper.

15 per cent. Phosphor Copper .. £70 above price B.S.

Phosphor Tin (5 per cent.) .. £30 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**			
98/99% purity, per lb.	—		
***Nickel.**			
In cubes, 98/99% purity Per ton	—		

	per lb.
Nickel Silver.	
Ingots for raising	—
Ingots for Spoons and Forks ..	—
" rolled to spoon size ..	—
***Tungsten Metal Powder.**	
96/98% purity.. per lb. ..	—
***Molybdenum Metal.**	
96/98% purity.. per lb. ..	—
***Cobalt Metal.**	
97% purity .. per lb. ..	—
Quicksilver.	
75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	s.	d.	s.	d.
Cleveland.				
Steel scrap, heavy melting..	—		—	
Iron scrap cast (cupola metal)	—		—	
London (f.o.b.).				
Heavy steel	108	6		
Light "	55	0		
Heavy cast	95	0		
Control Prices.				
Heavy Steel Melting Scrap 105	0		125	0
Steel Planings, Turnings and Borings	65	0		
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.	50	0		
Steel Scrap, all other Classes ..	95	0		
Wrought Iron Scrap	125	0		
Ditto, mixed with Steel	95	0		
W.I. Planings, Turnings and Borings mixed with Steel, &c.	50	0		

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	—		
Hy. Selected Scrap Brass ..	—		
Hy. Tinned Copper Wire	—		
Best Selected Gunmetal Scrap ..	—		
Re-melted Ingot Lead	—		

Stocks.

Metals.	Tons.
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	19,733

Coke.

	s.	d.	s.	d.
Middlesbrough.				
Gas Coke	36	0	—	
Foundry	52	6	—	
Glasgow.				
Foundry Coke	—		45	0
Furnace Coke	35	0	—	
Gas Coke	—			
London.				
Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6		

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	33	0
" foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs., & Midland Counties blast furnace	32	0
South Wales blast furnace ..	37	6
" foundry	50	6
All per ton net. f.o.t. ovens.		
Cumberland blast furnace	37	9
d/d West Coast furnaces		

SITUATIONS VACANT AND WANTED.

GENTLEMAN desires partnership in up-to-date Iron Foundry business; 25 years' practical experience. Capital, and excellent connection in the Manchester district.—Address, Box 956, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PATTERN MAKER.—Permanent position offered to suitable man in small controlled works, preferably one with experience in pattern-plate making for moulding machines. 50-hour week. No person already on Government work will be engaged.—Apply, your nearest Employment Exchange, mentioning No. A5353.

ADVERTISER, at present Foreman over a large Aircraft Foundry, desires change; experienced in all classes of machine moulding; highest references.—Address, Box 972, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN BRASSMOULDER seeks change, over four years in present employment; well up in greensand, drysand and loam; good experience of engine, ship and valve work, also aluminium; experienced in mixing alloys; six o'clock man; good controller of men; age 40 years.—Address, Box 970, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN BRASSMOULDER desires change Experienced in Mang. Bronze, Phos. Bronze, Gun Metal, and Aluminium. 13 years in present situation. Age 38.—Apply, Box 958, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PRACTICAL FOUNDRY MANAGER desires appointment; very wide and varied experience (gray iron, malleable and brass), motor, textile and general light castings trade; expert moulding machines and metals; good commercial experience; sound organiser; highest references.—Address, Box 974, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOUNDRY MANAGER—Iron and Bronze.—PETER BROTHERHOOD, LTD., Peterborough. would be pleased to receive applications for the position of Foundry Manager from thoroughly experienced men who have successfully controlled large foundries on high-grade work. Applications should be made in the first instance by letter, giving full particulars of experience and stating terms required. No person already employed on Government work can be engaged.

FRENCH REPRESENTATIVE, in position to sell very large quantities of PIG IRON after the War, wishes to get into touch with important firms.—Correspondence, in French, to Box 962, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

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MILAN (Italy).
Importers of
MINERALS. METALS. ALLOYS.
also
REFRACTORY MATERIALS and all requisites for the Engineering Trades.
Correspondence Invited.

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WANTED, Sand Blast Apparatus, in good working order.—Replies, stating age, condition, price, maker's size, etc., to Box 950, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WOOD-WOOL CORE ROPES for Sale; regular supplies.—Address, Box 960, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

ON SALE. — Coke-Fired Morgan Tilting Brass Furnace, in splendid condition, fan strap driven, will take 250 lbs. Crucible.—G. M. MARCHANT, LTD., Huddersfield.

WANTED, PIFTIN BLOWERS, all sizes. Please send particulars of where same can be seen. Advertisers are prepared to purchase any quantity.—Write, Box 968, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

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FURNISHERS
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FOUNDRY REQUISITES
Of every description.
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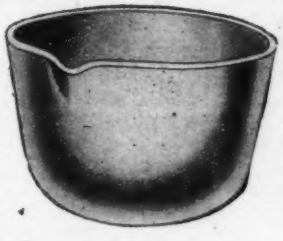
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Foundry Ladles
Plain or Lipped.
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PARTING. — PLUMBAGO.

WAX CORE VENTS.

METALLIC CEMENT. — **RESIN.** — GANISTER.

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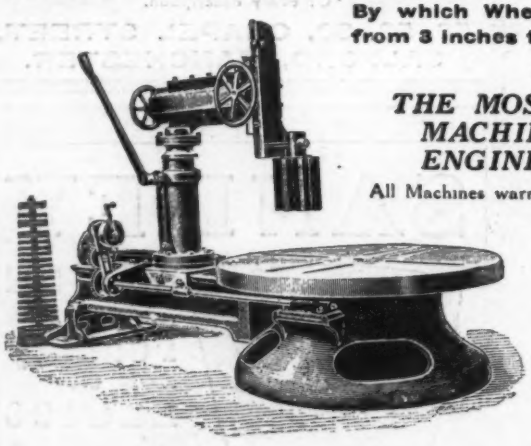
By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

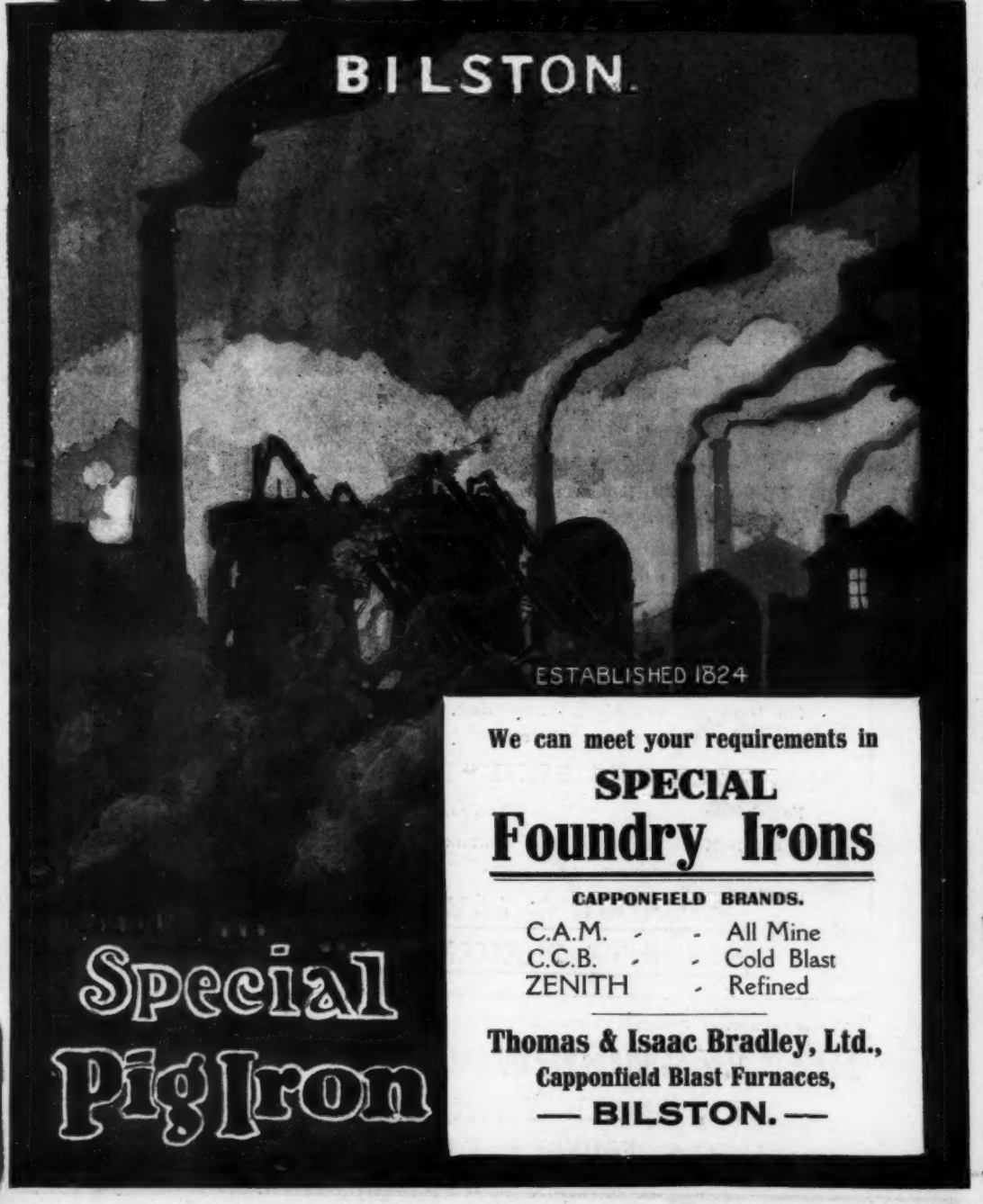
Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, ***OLDHAM.***

CAPPONFIELD



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SPECIAL

Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
C.C.B.	Cold Blast
ZENITH	Refined

Thomas & Isaac Bradley, Ltd.,
Capponfield Blast Furnaces,
— BILSTON. —

"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

FOUNDRITE SAVES MONEY.

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FOUNDRY CUPOLAS, LADLES,

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IMPROVED
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Full-economising
CUPOLAS.

FOUNDRY LADLES
from 28 lbs. capacity
to 10 tons ,,
A large number usually in stock.

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Also Makers of
Charging Platforms,
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Hoists, Cranes,
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From Photo of No. 4 Cupola complete with Tank-form Spark Arrester.
Made in all sizes from ¼ ton melting capacity to 15 tons per hour.

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Best Quality.

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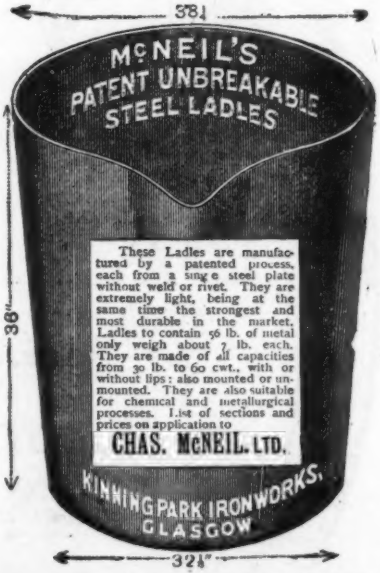
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McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS, GLASGOW
38"
32¼"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering

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Manufacturers of

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FOUNDRY REQUISITES of all kinds.

Specialities :

CORE GUM,
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SPADES,
SPRIGS.

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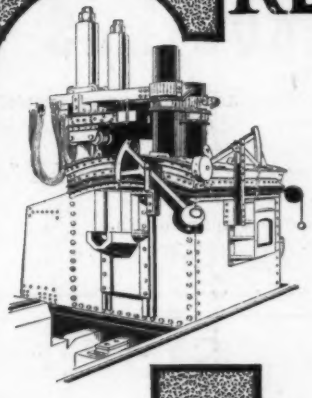
50, FOUNTAIN STREET (City),
MANCHESTER.

GREAVES-ETCHELLS Electric Furnace.



is a combination Arc and Resistance Furnace. The heat is applied both above and below the charge; the effect of this is to save rabbling, ensure quick melting and a most uniform quality of steel.

The Greaves-Etchells Furnace is simple, highly efficient, and is recognised by competent judges to be the furnace that gives the best results.

Used by the World's leading Steel Makers.

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FOUNDRY BLACKINGS

OF ALL KINDS,

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

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Our Specialite is Studying Special Requirements.

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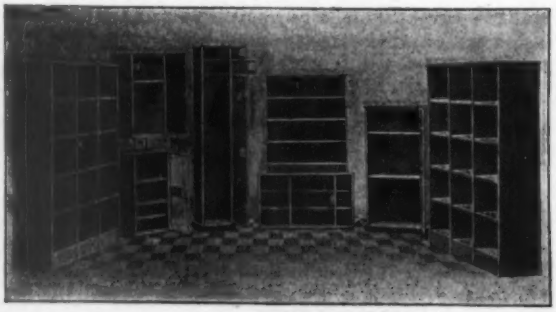

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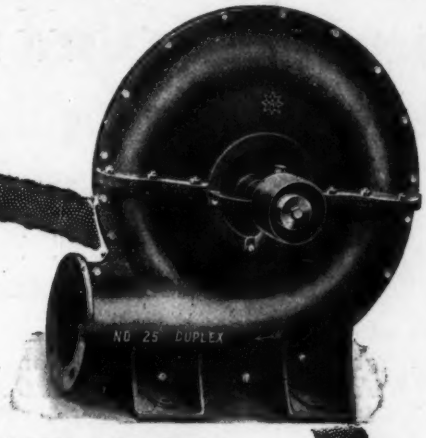

ALLDAYS

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BLOWERS, CRANES, CUPOLAS, FANS, MELTING FURNACES (oil, gas and coal fired), LADLES, SAND MIXERS, SMALL TOOLS, Etc., Etc.

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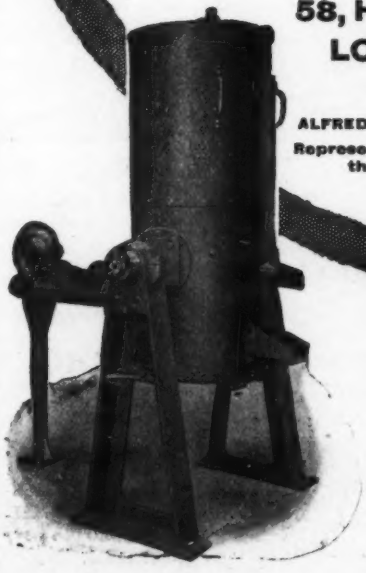

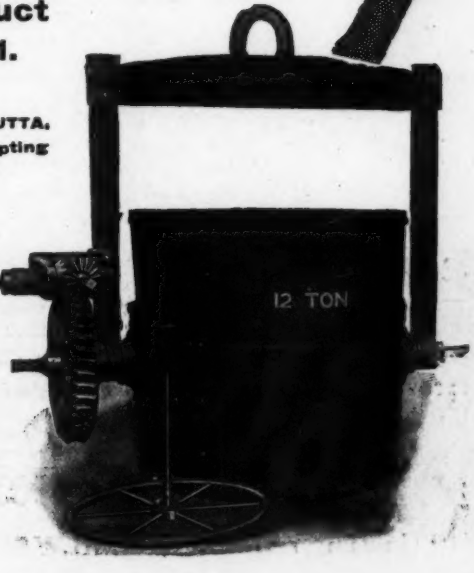

Semi-Steel is Used for the Very Lightest Pistons and Cylinders or the Heaviest Projectiles.

Many of the Steel Projectiles Do Not Burst

only the nose or head is blown out--proving the charge is too light or the shells are too strong. ***Semi-Steel Projectiles*** burst into ***1000 to 1200 Pieces*** while ***Semi-Steel Gears Wear Better Than Soft Steel*** or so-called ingot iron.

Every Tom, Dick and Harry thinks by throwing a little steel in the ladle or cupola—he is making semi-steel—***But Skill*** was used for years in perfecting our process and ***Brains*** are required to make it—***That's Why It Is Knocked.*** Many object to ideas they do not understand—semi-steel is no exception—like semi-steel, ***Scientific Melting*** is but little understood—***That's Why***

We Made Cupola Practice Fool Proof.

But there are foundrymen who still think it ***Mysterious*** because they run their cupola as their grandfathers did ***A Hundred Years Ago. Don't Say a Thing Can't be Done—The Fellow next door May Be Doing It.***

Don't use 50 to 60 per cent Pig Iron—Learn Our Way. If we Cannot Improve Your Product or Save You Some Money, There Is No Charge.

Why Waste Money ?

£15 pays for everything—***Report on Your Cupola*** —expert advice later on your shop practice—***Send Us Your Order NOW*** with the name of ***your Bank*** and we will forward you ***McLain's System Complete*** through ***Your Bank*** with ***Sight Draft Attached.***

McLain's System, Inc.

710 Goldsmith Building, MILWAUKEE, Wis., U.S.A.

SEMI-STEEL PROJECTILES SAVED FRANCE.

Type of 6, 8, 10 and 12-inch Projectiles now made of McLain's Semi-Steel, using 20 to 40 per cent steel.

T. & I. BRADLEY & SONS, LTD.,

DARLASTON, South Staffs.

SPECIAL COLD BLAST PIG IRONS.

Brands:

R.A.M. FOR CYLINDERS.

IXL. C.B.R. FOR CHILLED CASTINGS, &c.

D.M.R. CHARCOAL FOR MALLEABLE CASTINGS, &c.

* SELECTION * ANALYSIS * FRACTURE AND CHILL * GUARANTEED *

ALL MINE.	WARM BLAST.	COLD BLAST.
◆ A M ◆	I X L.	I X L.-CB.

☛ IF YOU HAVE DIFFICULTIES WITH YOUR SPECIAL CASTINGS CONSULT US.
We can put you right.

A SCRAP OF PAPER STARTED THIS AND SCRAP WILL FINISH IT!

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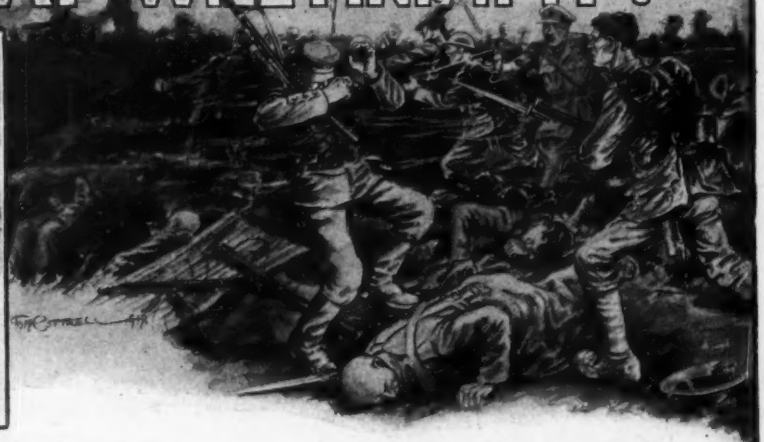

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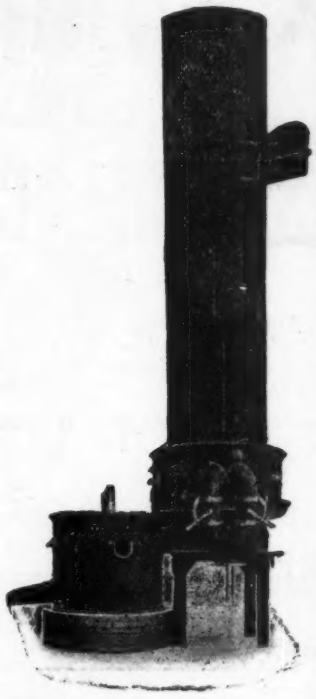

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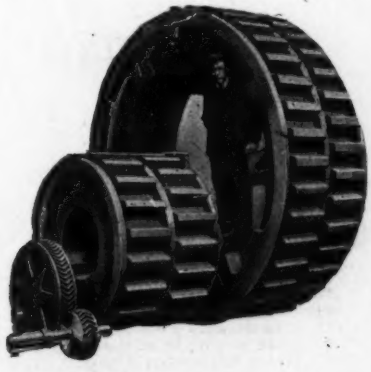

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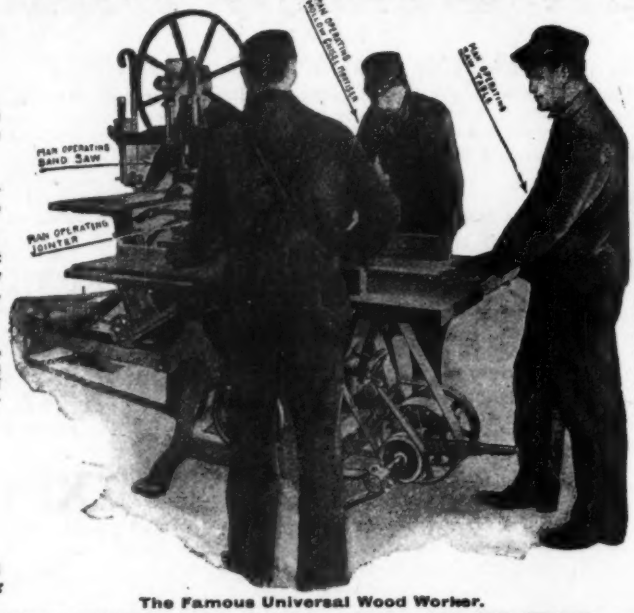

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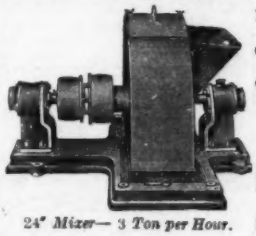

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